3.

PROCEEDINGS

OF

THE AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

THIRTY-EIGHTH MEETING,

HELD AT

TORONTO, ONTARIO,

AUGUST, 1889.

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FREDERICK W. PUTNAM,

Permanent Secretary.

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Page 250, in title of paper, for " Makoqueta " read Maquoketa.

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1st	April 2, 1840,	Philadelphia,	Edward Hitchcock,*	L. C. Beck,*		
2d	April 5, 1841,	Philadelphia,	Benjamin Silliman,*	L. C. Beck,*	B. Silliman, jr.,* C. B. Trego,*	
3d	April 25, 1842,	Boston,	S. G. Morton,*	C. T. Jackson,*	J. D. Whitney, M. B. Williams,*	
4th	April 26, 1843,	Albany,	Henry D. Rogers,*	B. Silliman, jr.,*		John Locke.*
5th	May 8, 1844,	Washington,	John Locke,*	B. Silliman, jr.,* O. P. Hubbard,		Douglas Houghton.*
6th	April 30, 1845,	New Haven,	Wm. B. Rogers,*	B. Silliman, jr.,* J. Lawrence Smith,*		Douglas Houghton.*
7th	Sept. 2, 1846,	New York,	C. T. Jackson,*	B. Silliman, jr.,*		E. C. Herrick.*
8th	Sept. 20, 1847,	Boston,	Wm. B. Rogers,†*	Jeffries Wyman,*		B. Silliman, jr.*

* Deceased.

† Professor ROGERS, as chairman of this last meeting, called the first meeting of the new Association to order and presided until it was fully organized by the adoption of a constitution. As he was thus the first presiding officer of the new Association, it was directed at the Hartford meeting that his name be placed at the head of the Past Presidents of the American Association for the Advancement of Science.

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MEETING.	DATE.	PLACE.	PRESIDENT.	VICE-PRESIDENT.	GENERAL SECRETARY.	PERMANENT SEC'Y.	TREASURER.
1st	Sept. 20, 1848,	Philadelphia, Pa.,	W. C. Redfield,*		Walter R. Johnson,*		Jeffries Wyman.*
2d	Aug. 14, 1849,	Cambridge, Mass.,	Joseph Henry,*		E. N. Horsford, 1		A. L. Elwyn.*
3d	Mar. 12, 1850,	Charleston, S. C.,	A. D. Bache,* 2		L. R. Gibbs, 3		St. J. Ravenel.* 4
4th	Aug. 19, 1850,	New Haven, Conn.,	A. D. Bache,*		E. C. Herrick,*		A. L. Elwyn.*
5th	May 5, 1851,	Cincinnati, Ohio,	A. D. Bache,*		W. B. Rogers, 5*	S. F. Baird,*	S. F. Baird. 6
6th	Aug. 19, 1851,	Albany, N. Y.,	Louis Agassiz,*		W. B. Rogers,*	S. F. Baird,*	A. L. Elwyn.*
7th	July 28, 1853,	Cleveland, Ohio,	Benjamin Pierce,*		S. St. John,* 7	S. F. Baird,*	A. L. Elwyn.*
8th	April 26, 1854,	Washington, D. C.,	J. D. Dana.		J. Lawrence Smith,*	Joseph Lovering,	J. L. LeConte* 8
9th	Aug. 15, 1855,	Providence, R. I.,	John Torrey,*		Wolcott Gibbs,	Joseph Lovering,	A. L. Elwyn.*
10th	Aug. 20, 1856,	Albany, N. Y.,	James Hall,		B. A. Gould,	Joseph Lovering,	A. L. Elwyn.*
11th	Aug. 12, 1857,	Montreal, Canada,	Alexis Caswell,* 9	Alexis Caswell,*	John LeConte,	Joseph Lovering,	A. L. Elwyn.*
12th	April 28, 1858,	Baltimore, Md.,	Alexis Caswell,* 10	John E. Holbrook,*†	W. M. Gillespie,* 11	Joseph Lovering,	A. L. Elwyn.*
13th	Aug. 3, 1859,	Springfield, Mass.,	Stephen Alexander,*	Edward Hitchcock,*	William Chauvenet,*	Joseph Lovering,	A. L. Elwyn.*
14th	Aug. 1, 1860,	Newport, R. I.,	Isaac Lea.*	B. A. Gould,	Joseph LeConte,	Joseph Lovering,	A. L. Elwyn.*
15th	Aug. 15, 1866,	Buffalo, N. Y.,	F. A. P. Barnard,*	A. A. Gould,* 12	Elias Loomis, 13	Joseph Lovering,	A. L. Elwyn.†*
16th	Aug. 21, 1867,	Burlington, Vt.,	J. S. Newberry,	Wolcott Gibbs,	C. S. Lyman,	Joseph Lovering,	A. L. Elwyn.†*
17th	Aug. 5, 1868,	Chicago, Ill.,	B. A. Gould,	Charles Whittlesey,*	Simon Newcomb, 14	Joseph Lovering,	A. L. Elwyn.†*
18th	Aug. 18, 1869,	Salem, Mass.,	J. W. Foster,*	O. N. Rood,	O. C. Marsh,	F. W. Putnam, 15	A. L. Elwyn.†*
19th	Aug. 17, 1870,	Troy, N. Y.,	T. S. Hunt, 16	T. S. Hunt,	F. W. Putnam, 17	Joseph Lovering,	A. L. Elwyn.†*
20th	Aug. 16, 1871,	Indianapolis, Ind.,	Asa Gray,*	G. F. Barker,	F. W. Putnam,	Joseph Lovering,	W. S. Vaux.*
21st	Aug. 15, 1872,	Dubuque, Iowa,	J. Lawrence Smith,*	Alex. Winchell,	E. S. Morse,	Joseph Lovering,	W. S. Vaux.*
22d	Aug. 20, 1873,	Portland, Me.,	Joseph Lovering,	A. H. Worthen,†*	C. A. White,	F. W. Putnam,	W. S. Vaux.*
23d	Aug. 12, 1874,	Hartford, Conn.,	J. L. LeConte,*	C. S. Lyman,*	A. C. Hamlin,	F. W. Putnam;	W. S. Vaux.†*

1. In place of Jeffries Wyman, *not present.*
2. In place of Joseph Henry, *not present.*
3. In place of E. C. Herrick, *not present.*
4. In place of A. L. Elwyn, *not present.*
5. In place of E. C. Herrick, *not present.*
6. In place of A. L. Elwyn, *not present.*
7. In place of J. D. Dana, *not present.*
8. In place of A. L. Elwyn, *not present.*
9. In place of J. W. Bailey, *deceased.*
10. In place of Jeffries Wyman, *not present.*
11. In place of Wm. Chauvenet, *not present.*
12. In place of R. W. Gibbes, *not present.*
13. In place of W. P. Trowbridge, *not present.*
14. In place of A. P. Rockwell, *called home 1st day.*
15. In place of Joseph Lovering, *in Europe.*
16. In place of Wm. Chauvenet, *too ill to be present.*
17. In place of C. F. Hartt, *in Brazil.*

* Deceased. † Not present at the meeting.

MEETINGS AND OFFICERS OF THE ASSOCIATION (Continued).

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENT, SECTION A.	VICE PRESIDENT, SECTION B.	CHAIRMAN OF PERMANENT SUBSECTION OF CHEMISTRY.	CHAIRMAN OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	CHAIRMAN OF PERMANENT SUBSECTION OF MICROSCOPY.	CHAIRMAN OF PERMANENT SUBSECTION OF ENTOMOLOGY.
24th	Aug. 11, 1875.	Detroit, Mich.,	J. E. Hilgard,	H. A. Newton,	J. W. Dawson,	S. W. Johnson,	L. H. Morgan,*	—	—
25th	Aug. 23, 1876.	Buffalo, N. Y.,	W. B. Rogers,*	C. A. Young,	E. S. Morse,	G. F. Barker,	L. H. Morgan,*	R. H. Ward,	—
26th	Aug. 29, 1877.	Nashville, Tenn.,	S. Newcomb,	R. H. Thurston,[1]	O. C. Marsh,	N. T. Lupton,	Daniel Wilson,†	R. H. Ward,	—
27th	Aug. 21, 1878.	St. Louis, Mo.,	O. C. Marsh,	R. H. Thurston,	Aug. R. Grote,	F. W. Clarke,	—[3]	R. H. Ward,[3]	—
28th	Aug. 27, 1879.	Saratoga, N. Y.,	G. F. Barker,	S. P. Langley,	J. W. Powell,	F. W. Clarke,[4]	Daniel Wilson,	E. W. Morley,	—
29th	Aug. 25, 1880.	Boston, Mass.,	L. H. Morgan,*	Asaph Hall,	Alex. Agassiz,	J. M. Ordway,	J. W. Powell,	R. A. Lattimore,	—
30th	Aug. 17, 1881.	Cincinnati, Ohio,	G. J. Brush,	Wm. Harkness,[7]	E. T. Cox,[8]	G. C. Caldwell,[9]	G. Mallery,	A. B. Hervey,	J. G. Morris.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF SECTION A.	SECRETARY OF SECTION B.	SECRETARY OF PERMANENT SUBSECTION OF CHEMISTRY.	SECRETARY OF PERMANENT SUBSECTION OF ANTHROPOLOGY.	SECRETARY OF PERMANENT SUBSECTION OF MICROSCOPY.	SECRETARY OF PERMANENT SUBSECTION OF ENTOMOLOGY.	TREASURER.
F. W. Putnam,	S. H. Scudder,	S. P. Langley, T. C. Mendenhall,	E. S. Morse,	F. W. Clarke,	F. W. Putnam,	—	—	W. S. Vaux.*
F. W. Putnam,	T. C. Mendenhall,	A. W. Wright,	Albert H. Tuttle,	H. C. Bolton,	O. T. Mason,	E. W. Morley,	—	W. S. Vaux.*
F. W. Putnam,	Aug. R. Grote,	H. C. Bolton,	Wm. H. Dall,	P. Schweitzer,	—[8]	T. O. Summers, Jr.,	—	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,	F. E. Nipher,	George Little,	A. P. S. Stuart,	—[8]	G. J. Engelmann,	—	W. S. Vaux.†*
F. W. Putnam,	H. C. Bolton,[5]	J. K. Rees,	W. H. Dall,[6]	W. R. Nichols,*	J. G. Henderson,	A. B. Hervey,	—	W. S. Vaux.†*
F. W. Putnam,	J. K. Rees,	H. B. Mason,	C. V. Riley,	C. E. Munroe,	J. G. Henderson,	A. B. Hervey,	—	W. S. Vaux.*
F. W. Putnam,	C. V. Riley,	E. T. Tappan,[10]	Wm. Saunders,	A. Springer,[12]	J. G. Henderson,	W. H. Seaman,[11]	B. P. Mann,	W. S. Vaux.†*

1 In the absence of E. C. Pickering.
2 In the absence of Ira Remsen.
7 In the absence of A. M. Mayer.
10 In the absence of John Trowbridge.
* Deceased.

3 The Subsection united with Sec. B.
5 In the absence of George Little.
8 In the absence of George Engelmann.
11 In the absence of S. P. Sharples.
† Not present.

4 In the absence of G. S. Blackie.
6 In the absence of A. C. Wetherby.
9 In the absence of W. R. Nichols.
12 In place of H. W. Wiley, called away.

MEETINGS AND OFFICERS OF THE ASSOCIATION. (*Continued.*)

MEETING.	DATE.	PLACE.	PRESIDENT.	VICE PRESIDENTS. Section A.	Section B.	Section C.	Section D.	Section E.
31st	Aug. 23, 1882.	Montreal, Can.	J. W. Dawson,	W. A. Rogers,[1]	T.C. Mendenhall,	H. C. Bolton,	W. P. Trowbridge,	E. T. Cox,
32nd	Aug. 15, 1883.	Minneapolis, M.	C. A. Young,	W. A. Rogers,	H. A. Rowland,	E. W. Morley,	De Volsen Wood,[7]	C.H. Hitchcock,
33rd	Sept. 3, 1884.	Philadelphia, Pa.	J. P. Lesley,	H. T. Eddy,	J. Trowbridge,	J. W. Langley,	R. H. Thurston,	N. H. Winchell,
34th	Aug. 26, 1885.	Ann Arbor, Mich.	H. A. Newton,	W. Harkness,[15]	S. P. Langley,[16]	N. T. Lupton,[17]	J. Burkitt Webb,	Edward Orton,
35th	Aug. 18, 1886.	Buffalo, N. Y.	E. S. Morse,	J. W. Gibbs,	C. F. Brackett,	H. W. Wiley,	O Chanute,	T. C Chamberlin,
36th	Aug. 10, 1887.	New York, N. Y.	S. P. Langley,	J. R. Eastman,[26]	W. A. Anthony,	A. B. Prescott	E. B. Coxe,	G. K. Gilbert,

VICE PRESIDENTS. Section F.	Section G.	Section H.	Section I.	Permanent Secretary.	General Secretary.	Assistant Gen. Secretary.	SECRETARIES OF SECTIONS. Section A.	Section B.
W. H. Dall,	A. H. Tuttle,	Alex. Winchell,[2]	E. B. Elliott,	F. W. Putnam.	Wm. Saunders.	J. R. Eastman.	H. T. Eddy,	C. S. Hastings,
W. J. Beal,	J. D. Cox,	O. T. Mason,	F. B. Hough,*	F. W. Putnam.	J. R. Eastman.	Alfred Springer,	G. W. Hough,[8]	F. E. Nipher,[9]
E. D. Cope,	T. G. Wormley,	E. S. Morse,	John Eaton,	F. W. Putnam.	Alfred Springer,	C. S. Minot,[12]	G. W. Hough,	N. D. C. Hodges,
T. J. Burrill,[18]	S. H. Gage,	J. O. Dorsey,[19]	Edw. Atkinson	F. W. Putnam.	C. S. Minot,	S. G. Williams,[20]	E. W. Hyde.	B. F. Thomas,[21]
H. P. Bowditch,	———[25]	H. Hale,	Jos. Cummings	F. W. Putnam.	S. G. Williams,	W. H. Pettee,	S. C. Chandler,	H. S. Carhart,
W. G. Farlow,	———	D. G. Brinton,	H. E. Alvord,	F. W. Putnam.	W. H. Pettee,	J. C. Arthur,	H. M. Paul,	C. Leo Mees,

SECRETARIES OF THE SECTIONS. Section C.	Section D	Section E.	Section F.	Section G.	Section H.	Section I.	Treasurer.
Alfred Springer,	J. B. Webb,[3]	H. S. Williams,[4]	Wm. Osler,[5]	Robt. Brown, jr.,	O. T. Mason.	F. B. Hough,[6]*	———*
J. W. Langley,[10]	J. B. Webb,[11]	A. A. Julien,	S. A. Forbes,	Carl Seiler,	G. H. Perkins,	Jos. Cummings,	William Lilly.
H. Carmichael,[13]	J. B. Webb,	E. A. Smith,	C. E. Bessey,	R. Hitchcock,	G. H. Perkins,[14]	C. W. Smiley,	William Lilly.
F.P. Dunnington,	C. J. H. Woodbury,	G. K. Gilbert,[22]	J. A. Lintner,[23]	W. H. Walmsley,	Erm. A. Smith,*	C. W. Smiley,[24]	William Lilly.
W. McMurtrie,	William Kent,	E. W. Claypole,	J. C. Arthur,	———[25]	A. W. Butler,	H. E. Alvord,	William Lilly.
C. S. Mabery,[27]	G. M. Bond,	W. M. Davis,[28]	J. H. Comstock,	———	C. C. Abbott,[29]	W. R. Lazenby,	William Lilly.

1 In the absence of William Harkness.
2 In the absence of Daniel Wilson.
3 In the absence of C. B. Dudley.
4 In the absence of C. E. Dutton.
5 In the absence of C. S. Minot.
6 F. B. Hough was called home and J. R. Dodge acted at the close of the meeting.
7 Absent but place was not filled.
8 In the absence of W. W. Johnson.
9 In the absence of C. K. Wead.
10 W. M. McMurtrie, last three days of meeting.
11 Pro tempore.
12 In the absence of E. S. Holden.
13 In the absence of R. B. Warder.
14 In the absence of W. H. Holmes.
15 In the absence of J. M. Van Vleck.
16 In place of C. F. Brackett, resigned.
17 In the absence of W. R. Nichols.
18 In the absence of B. G. Wilder.
19 In the absence of W. H. Dall.
20 In place of C. C. Abbott, not present
21 In place of A.A. Michelson, resigned.
22 In the absence of H. C. Lewis.
23 In place of C. H. Fernald, resigned.
24 In the absence of J. W. Chickering.
25 Section permanently united to Section F.
26 In place of W. Ferrel, resigned.
27 Absent; R. B. Warder acted as Sec'y pro tem.
28 In place of T. B. Comstock, absent.
29 In place of F. W. Langdon, absent.

*Deceased.

MEETINGS AND OFFICERS OF THE ASSOCIATION (*Continued*).

MEETING.	DATE.	PLACE.	PRESIDENT.
37th.	Aug. 15, 1888.	Cleveland, Ohio.	J. W. Powell.
38th.	Aug. 27, 1889.	Toronto, Ontario.	T. C. Mendenhall.

VICE PRESIDENTS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
Ormond Stone.	A. A. Michelson.	C. E. Munroe.	C. J. H. Woodbury.
R. S. Woodward.	H. S. Carhart.	W. L. Dudley.	James E. Denton.

SECTION E.	SECTION F.	SECTION H.	SECTION I.
George H. Cook.	C. V. Riley.	C. C. Abbott.	C. W. Smiley.
Charles A. White.	Geo. L. Goodale.	Garrick Mallery.	Charles S. Hill.

PERMANENT SECRETARY.	GENERAL SECRETARY.	SECRETARY OF COUNCIL.	TREASURER.
F. W. Putnam.	Julius Pohlman.	C. Leo Mees.	William Lilly.
F. W. Putnam.	C. Leo Mees.	H. C. Bolton.	William Lilly.

SECRETARIES OF SECTIONS.

SECTION A.	SECTION B.	SECTION C.	SECTION D.
C. C. Doolittle.	A. Macfarlane.	W. L. Dudley.	Arthur Beardsley.
G. C. Comstock.	E. L. Nichols.	Edward Hart.	W. B. Warner.

SECTION E.	SECTION F.	SECTION H.	SECTION I.
John C. Branner.	B. H. Fernow.	Frank Baker.	Charles S. Hill.
John C. Branner.	A. W. Butler.	W. M. Beauchamp.	J. R. Dodge.

MEETINGS.	PLACE.	YEAR.	MEMBERS IN ATTENDANCE.	NUMBER OF MEMBERS.
1.	Philadelphia	1848	?	461
2.	Cambridge	1849	?	540
3.	Charleston	1850	?	622
4.	New Haven	1850	?	704
5.	Cincinnati	1851	87	800
6.	Albany	1851	194	769
7.	Cleveland	1853	?	940
8.	Washington	1854	168	1004
9.	Providence	1855	166	605
10.	2nd Albany	1856	381	722
11.	Montreal	1857	351	946
12.	Baltimore	1858	190	962
13.	Springfield	1859	190	862
14.	Newport	1860	135	644
15.	Buffalo	1866	79	637
16.	Burlington	1867	73	415
17.	Chicago	1868	259	686
18.	Salem	1869	244	511
19.	Troy	1870	188	536
20.	Indianapolis	1871	196	668
21.	Dubuque	1872	164	610
22.	Portland	1873	195	670
23.	Hartford	1874	224	722
24.	Detroit	1875	165	807
25.	2nd Buffalo	1876	215	867
26.	Nashville	1877	173	953
27.	St. Louis	1878	134	962
28.	Saratoga	1879	256	1030
29.	Boston	1880	997	1555
30.	2nd Cincinnati	1881	500	1699
31.	2nd Montreal	1882	937	1922
32.	Minneapolis	1883	328	2033
33.	2nd Philadelphia	1884	1261*	1981
34.	Ann Arbor	1885	364	1956
35.	3d Buffalo	1886	445	1886
36.	New York	1887	729	1955
37.	2nd Cleveland	1888	342	1964
38.	Toronto	1889	424	1952

*Including members of the British Association and other foreign guests.

COMMONWEALTH OF MASSACHUSETTS.

IN THE YEAR ONE THOUSAND EIGHT HUNDRED AND SEVENTY-FOUR.

AN ACT

TO INCORPORATE THE "AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE."

Be it enacted by the Senate and House of Representatives, in General Court assembled, and by the authority of the same, as follows:

SECTION 1. Joseph Henry of Washington, Benjamin Pierce of Cambridge, James D. Dana of New Haven, James Hall of Albany, Alexis Caswell of Providence, Stephen Alexander of Princeton, Isaac Lea of Philadelphia, F. A. P. Barnard of New York, John S. Newberry of Cleveland, B. A. Gould of Cambridge, T. Sterry Hunt of Boston, Asa Gray of Cambridge, J. Lawrence Smith of Louisville, Joseph Lovering of Cambridge and John LeConte of Philadelphia, their associates, the officers and members of the Association, known as the "American Association for the Advancement of Science," and their successors, are hereby made a corporation by the name of the "American Association for the Advancement of Science," for the purpose of receiving, purchasing, holding and conveying real and personal property, which it now is, or hereafter may be, possessed of, with all the powers and privileges, and subject to the restrictions, duties and liabilities set forth in the general laws which now or hereafter may be in force and applicable to such corporations.

SECTION 2. Said corporation may have and hold by purchase, grant, gift or otherwise, real estate not exceeding one hundred thousand dollars in value, and personal estate of the value of two hundred and fifty thousand dollars.

SECTION 3. Any two of the corporators above named are hereby authorized to call the first meeting of the said corporation in the month of August next ensuing, by notice thereof "by mail," to each member of the said Association.

SECTION 4. This act shall take effect upon its passage.

HOUSE OF REPRESENTATIVES, March 10, 1874.
Passed to be enacted,
JOHN E. SANFORD, *Speaker*.

IN SENATE, March 17, 1874.
Passed to be enacted,
GEO. B. LORING, *President*.

March 19, 1874.
Approved,
W. B. WASHBURN.

SECRETARY'S DEPARTMENT,
Boston, April 8, 1874.
A true copy, Attest:
DAVID PULSIFER,
Deputy Secretary of the Commonwealth.

CONSTITUTION

OF THE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

Incorporated by Act of the General Court of the Commonwealth of Massachusetts.

OBJECTS.

ARTICLE 1. The objects of the Association are, by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of America, to give a stronger and more general impulse and more systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness.

MEMBERS, FELLOWS, PATRONS AND HONORARY FELLOWS.

ART. 2. The Association shall consist of Members, Fellows, Patrons, and Honorary Fellows.

ART. 3. Any person may become a Member of the Association upon recommendation in writing by two members or fellows, and election by the Council.

ART. 4. Fellows shall be elected by the Council from such of the members as are professionally engaged in science, or have by their labors aided in advancing science. The election of fellows shall be by ballot and a majority vote of the members of the Council at a designated meeting of the Council.

ART. 5. Any person paying to the Association the sum of one thousand dollars shall be classed as a Patron, and shall be entitled to all the privileges of a member and to all its publications.

ART. 6. Honorary Fellows of the Association, not exceeding three for each section, may be elected; the nominations to be made by the Council and approved by ballot in the respective sections before election by ballot in General Session. Honorary Fellows shall be entitled to all the privi-

leges of Fellows and shall be exempt from all fees and assessments, and entitled to all publications of the Association issued after the date of their election.

Art. 7. The name of any member or fellow two years in arrears for annual dues shall be erased from the list of the Association, provided that two notices of indebtedness, at an interval of at least three months, shall have been given; and no such person shall be restored until he has paid his arrearages or has been reëlected. The Council shall have power to exclude from the Association any member or fellow, on satisfactory evidence that said member or fellow is an improper person to be connected with the Association, or has in the estimation of the Council made improper use of his membership or fellowship.

Art. 8. No member or fellow shall take part in the organization of, or hold office in, more than one section at any one meeting.

Officers.

Art. 9. The Officers of the Association shall be elected by ballot in General Session from the fellows, and shall consist of a President, a Vice President from each section, a Permanent Secretary, a General Secretary, a Secretary of the Council, a Treasurer, and a Secretary of each Section; these, with the exception of the Permanent Secretary, shall be elected at each meeting for the following one, and, with the exception of the Treasurer and the Permanent Secretary, shall not be reëligible for the next two meetings. The term of office of Permanent Secretary shall be five years.

Art. 10. The President, or, in his absence, the senior Vice President present, shall preside at all General Sessions of the Association and at all meetings of the Council. It shall also be the duty of the President to give an address at a General Session of the Association at the meeting following that over which he presided.

Art. 11. The Vice Presidents shall be the chairmen of their respective Sections, and of their Sectional Committees, and it shall be part of their duty to give an address, each before his own section, at such time as the Council shall determine. The Vice Presidents may appoint temporary chairmen to preside over the sessions of their sections, but shall not delegate their other duties. The Vice Presidents shall have seniority in order of their continuous membership in the Association.

Art. 12. The General Secretary shall be the Secretary of all General Sessions of the Association, and shall keep a record of the business of

these sessions. He shall receive the records from the Secretaries of the Sections, which, after examination, he shall transmit with his own records to the Permanent Secretary within two weeks after the adjournment of the meeting.

ART. 13. The Secretary of the Council shall keep the records of the Council. He shall give to the Secretary of each Section the titles of papers assigned to it by the Council. He shall receive proposals for membership and bring them before the Council.

ART. 14. The Permanent Secretary shall be the executive officer of the Association under the direction of the Council. He shall attend to all business not specially referred to committees nor otherwise constitutionally provided for. He shall keep an account of all business that he has transacted for the Association, and make annually a general report for publication in the annual volume of Proceedings. He shall attend to the printing and distribution of the annual volume of Proceedings, and all other printing ordered by the Association. He shall issue a circular of information to members and fellows at least three months before each meeting, and shall, in connection with the Local Committee, make all necessary arrangements for the meetings of the Association. He shall provide the Secretaries of the Association with such books and stationery as may be required for their records and business, and shall provide members and fellows with such blank forms as may be required for facilitating the business of the Association. He shall collect all assessments and admission fees, and notify members and fellows of their election, and of any arrearages. He shall receive, and bring before the Council, the titles and abstracts of papers proposed to be read before the Association. He shall keep an account of all receipts and expenditures of the Association, and report the same annually at the first meeting of the Council, and shall pay over to the Treasurer such unexpended funds as the Council may direct. He shall receive and hold in trust for the Association all books, pamphlets and manuscripts belonging to the Association, and allow the use of the same under the provisions of the Constitution and the orders of the Council. He shall receive all communications addressed to the Association during the interval between meetings, and properly attend to the same. He shall at each meeting report the names of fellows and members who have died since the preceding meeting. He shall be allowed a salary which shall be determined by the Council, and may employ one or more clerks at such compensation as may be agreed upon by the Council.

ART. 15. The Treasurer shall invest the funds received by him in such securities as may be directed by the Council. He shall annually present to the Council an account of the funds in his charge. No expenditure of the principal in the hands of the Treasurer shall be made without a unanimous vote of the Council, and no expenditure of the income received by the Treasurer shall be made without a two-thirds vote of the Council.

ART. 16. The Secretaries of the Sections shall keep the records of their respective sections, and, at the close of the meeting, give the same, including the records of subsections, to the General Secretary. They shall also be the Secretaries of the Sectional Committees. The Secretaries shall have seniority in order of their continuous membership in the Association.

ART. 17. In case of a vacancy in the office of the President, one of the Vice Presidents shall be elected by the Council as the President of the meeting. Vacancies in the offices of Vice President, Permanent Secretary, General Secretary, Secretary of the Council, and Treasurer, shall be filled by nomination of the Council and election by ballot in General Session. A vacancy in the office of Secretary of a Section shall be filled by nomination and election by ballot in the Section.

ART. 18. The Council shall consist of the past Presidents, and the Vice Presidents of the last meeting, together with the President, the Vice Presidents, the Permanent Secretary, the General Secretary, the Secretary of the Council, the Secretaries of the Sections, and the Treasurer of the current meeting, with the addition of one fellow elected from each Section by ballot on the first day of its meeting. The members present at any regularly called meeting of the Council, provided there are at least five, shall form a quorum for the transaction of business. The Council shall meet on the day preceding each annual meeting of the Association, and arrange the programme for the first day of the sessions. The time and place of this first meeting shall be designated by the Permanent Secretary. Unless otherwise agreed upon, regular meetings of the Council shall be held in the council room at 9 o'clock, A.M., on each day of the meeting of the Association. Special meetings of the Council may be called at any time by the President. The Council shall be the board of supervision of the Association, and no business shall be transacted by the Association that has not first been referred to, or originated with, the Council. The Council shall receive and assign papers to the respective sections; examine and, if necessary, exclude papers; decide which papers,

discussions and other proceedings shall be published, and have the general direction of the publications of the Association; manage the financial affairs of the Association; arrange the business and programmes for General Sessions; suggest subjects for discussion, investigation or reports; elect members and fellows; and receive and act upon all invitations extended to the Association and report the same at a General Session of the Association. The Council shall receive all reports of Special Committees and decide upon them, and only such shall be read in General Session as the Council shall direct. The Council shall appoint at each meeting the following sub-committees who shall act, subject to appeal to the whole Council, until their successors are appointed at the following meeting: 1, on Papers and Reports; 2, on Members; 3, on Fellows.

ART. 19. The Nominating Committee shall consist of the Council, and one member or fellow elected by each of the Sections. It shall be the duty of this Committee to meet at the call of the President and nominate the general officers for the following meeting of the Association. It shall also be the duty of this Committee to recommend the time and place for the next meeting. The Vice President and Secretary of each Section shall be recommended to the Nominating Committee by a sub-committee consisting of the Vice President, Secretary, and three members or fellows elected by the Section.

MEETINGS.

ART. 20. The Association shall hold a public meeting annually, for one week or longer, at such time and place as may be determined by vote of the Association, and the preliminary arrangements for each meeting shall be made by the Local Committee, in conjunction with the Permanent Secretary and such other persons as the Council may designate.

ART. 21. A General Session shall be held at 10 o'clock A. M., on the first day of the meeting, and at such other times as the Council may direct.

SECTIONS AND SUBSECTIONS.

ART. 22. The Association shall be divided into Sections, namely:—A, *Mathematics and Astronomy;* B, *Physics;* C, *Chemistry, including its application to agriculture and the arts;* D, *Mechanical Science and Engineering;* E, *Geology and Geography;* F, *Biology;* [G, united to section F]; H, *Anthropology;* I, *Economic Science and Statistics.* The Council shall have power to consolidate any two or more Sections temporarily, and such consolidated Sections shall be presided over by the senior Vice President and Secretary of the Sections comprising it.

Art. 23. Immediately on the organization of a Section there shall be three fellows elected by ballot after open nomination, who, with the Vice President and Secretary, shall form its Sectional Committee. The Sectional Committees shall have power to fill vacancies in their own numbers. Meetings of the Sections shall not be held at the same time with a General Session.

Art. 24. The Sectional Committee of any Section may at its pleasure form one or more temporary Subsections, and may designate the officers thereof. The Secretary of a Subsection shall, at the close of the meeting, transmit his records to the Secretary of the Section.

Art. 25. A paper shall not be read in any Section or Subsection until it has been received from the Council and placed on the programme of the day by the Sectional Committee.

Sectional Committees.

Art. 26. The Sectional Committees shall arrange and direct the business of their respective Sections. They shall prepare the daily programmes and give them to the Permanent Secretary for printing at the earliest moment practicable. No titles of papers shall be entered on the daily programmes except such as have passed the Council. No change shall be made in the programme for the day in a Section without the consent of the Sectional Committee. The Sectional Committees may refuse to place the title of any paper on the programme; but every such title, with the abstract of the paper or the paper itself, must be returned to the Council with the reasons why it was refused.

Art. 27. The Sectional Committees shall examine all papers and abstracts referred to the sections, and they shall not place on the programme any paper inconsistent with the character of the Association; and to this end they have power to call for any paper, the character of which may not be sufficiently understood from the abstract submitted.

Papers and Communications.

Art. 28. All members and fellows must forward to the Permanent Secretary, as early as possible, and when practicable before the convening of the Association, full titles of all the papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery, and also such abstracts of their contents as will give a general idea of their nature; and no title shall be referred by the Council to the Sectional Committee until an abstract of the paper or the paper itself has been received.

Art. 29. If the author of any paper be not ready at the time assigned, the title may be dropped to the bottom of the list.

ART. 30. Whenever practicable, the proceedings and discussions at General Sessions, Sections and Subsections shall be reported by professional reporters, but such reports shall not appear in print as the official reports of the Association unless revised by the Secretaries.

PRINTED PROCEEDINGS.

ART. 31. The Permanent Secretary shall have the Proceedings of each meeting printed in an octavo volume as soon after the meeting as possible, beginning one month after adjournment. Authors must prepare their papers or abstracts ready for the press, and these must be in the hands of the Secretaries of the Sections before the final adjournment of the meeting, otherwise only the titles will appear in the printed volume. The Council shall have power to order the printing of any paper by abstract or title only. Whenever practicable, proofs shall be forwarded to authors for revision. If any additions or substantial alterations are made by the author of a paper after its submission to the Secretary, the same shall be distinctly indicated. Illustrations must be provided for by the authors of the papers, or by a special appropriation from the Council. Immediately on publication of the volume, a copy shall be forwarded to every member and fellow of the Association who shall have paid the assessment for the meeting to which it relates, and it shall also be offered for sale by the Permanent Secretary at such price as may be determined by the Council. The Council shall also designate the institutions to which copies shall be distributed.

LOCAL COMMITTEE.

ART. 32. The Local Committee shall consist of persons interested in the objects of the Association and residing at or near the place of the proposed meeting. It is expected that the Local Committee, assisted by the officers of the Association, will make all essential arrangements for the meeting, and issue a circular giving necessary particulars, at least one month before the meeting.

LIBRARY OF THE ASSOCIATION.

ART. 33. All books and pamphlets received by the Association shall be in the charge of the Permanent Secretary, who shall have a list of the same printed and shall furnish a copy to any member or fellow on application. Members and fellows who have paid their assessments in full shall be allowed to call for books and pamphlets, which shall be delivered to them at their expense, on their giving a receipt agreeing to make good any loss or damage and to return the same free of expense to the Secretary at the time specified in the receipt given. All books and pamphlets

in circulation must be returned at each meeting. Not more than five books, including volumes, parts of volumes, and pamphlets, shall be held at one time by any member or fellow. Any book may be withheld from circulation by order of the Council.

ADMISSION FEE AND ASSESSMENTS.

ART. 34. The admission fee for members shall be five dollars in addition to the annual assessment. On the election of any member as a fellow an additional fee of two dollars shall be paid.

ART. 35. The annual assessment for members and fellows shall be three dollars.

ART. 36. Any member or fellow who shall pay the sum of fifty dollars to the Association, at any one time, shall become a Life Member and as such shall be exempt from all further assessments, and shall be entitled to the Proceedings of the Association. All money thus received shall be invested as a permanent fund, the income of which, during the life of the member, shall form a part of the general fund of the Association; but, after his death, shall be used only to assist in original research, unless otherwise directed by unanimous vote of the Council.

ART. 37. All admission fees and assessments must be paid to the Permanent Secretary, who shall give proper receipts for the same.

ACCOUNTS.

ART. 38. The accounts of the Permanent Secretary and of the Treasurer shall be audited annually, by Auditors appointed by the Council.

ALTERATIONS OF THE CONSTITUTION.

ART. 39. No part of this Constitution shall be amended or annulled, without the concurrence of three-fourths of the members and fellows present in General Session, after notice given at a General Session of a preceding meeting of the Association.

ORDER OF PROCEEDINGS IN ORGANIZING A MEETING.

1. The retiring President introduces the President elect, who takes the chair.
2. Formalities of welcome of the Association as may be arranged by the Local Committee.
3. Report of the list of papers entered and their reference to the Sections.
4. Other reports.
5. Announcements of arrangements by the Local Committee.
6. Announcements of Elections by the Council.
7. Unenumerated business.
8. Adjournment to meet in Sections.

This order, so far as applicable, to be followed in subsequent General Sessions.

MEMBERS

OF THE

AMERICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE.[1]

PATRONS.[2]

THOMPSON, MRS. ELIZABETH, Stamford, Conn. (22).
LILLY, GEN. WILLIAM, Mauch Chunk, Carbon Co., Pa. (28) **F H**
HERRMAN, MRS. ESTHER, 59 West 56th St., New York, N. Y. (29).

MEMBERS.[3]

Abbe, Robert, 11 W. 50th St., New York, N. Y. (36).
Abert, S. Thayer, 810 19th St., N. W., Washington, D. C. (30). **A B D H I**
Abrey, George Burchutt, C.E., Toronto, Ontario, Can. (38).
Adams, W. H., Consulting Engineer, 71 Wall St., New York, N. Y. (36).
Agard, Dr. A. H., 1259 Alice St., Oakland, Alameda Co., Cal. (28).
Alden, Jno., Pacific Mills, Lawrence, Mass. (36).

[1] The numbers in parentheses indicate the meeting at which the member was elected. The black letters at the end of line indicate the sections to which members elect to belong. The Constitution requires that the names of all members two or more years in arrears shall be omitted from the list, but their names will be restored on payment of arrearages. Members not in arrears are entitled to the annual volume of Proceedings bound in paper. *The payment of ten dollars at one time entitles a member to the subsequent volumes to which he may be entitled, bound in cloth, or by the payment of twenty dollars, to such volumes bound in half morocco.*

[2] Persons contributing one thousand dollars or more to the Association are classed as Patrons, and are entitled to the privileges of members and to the publications. The names of Patrons are to remain permanently on the list.

[3] Any Member or Fellow may become a Life Member by the payment of fifty dollars. The income of the money derived from a Life Membership is used for the general purposes of the Association during the life of the member; afterwards it is to be used to aid in original research. Life Members are exempt from the annual assessment, and are entitled to the annual volume. The names of Life Members are printed in small capitals in the regular list of Members and Fellows.

Allderdice, Wm. H., Ass't Eng. U. S. N., U. S. Naval Academy, Annapolis, Md. (33). D
Allen, Addison, 50 Wall St., New York, N. Y. (36).
Allen, Dudley P., M.D., 278 Prospect St., Cleveland, Ohio (36) F
Allen, J. M., Hartford, Conn. (22). D
Allen, W. F., 46 Bond St., New York, N. Y. (36).
Alvord, Benjamin, 2nd Lt., U. S. A., West Point, N. Y. (33). A
Ammidown, Edward H., P. O. Box 2739, New York, N. Y. (37).
Anderson, Alexander D., Washington, D. C. (38).
Anderson, Newton M., 371 Sibley St., Cleveland, Ohio (30). B
Angell, Geo. W. J., 44 Hudson St., New York, N. Y. (36).
Ansley, Clark F., Swedona, Mercer Co., Ill. (32). E H
Antisell, Thomas, M.D., 1311 Q St., N. W., Washington, D. C. (33) C E
Appleton, Rev. Edw. W., D.D., Ashbourne P. O., Montgomery Co., Pa. (28).
Archambault, U. E., P. O. Box 1944, Montreal, P. Q., Can. (31).
Ashley, Prof. William James, 29 Harbord St., Toronto, Ontario, Can. (38).
Atkinson, Jno. B., Earlington, Hopkins Co., Ky. (26). D
Atterbury, Rev. Anson Phelps, 117 W. 87th St., New York, N. Y. (36). E
Atwell, Charles B., 461 Emerson St., Evanston, Ill. (36). F
Atwood, E. S., East Orange, N. J. (29). F
Austin, Wm., Belvidere House, 4th Ave., cor. 18th St., New York, N. Y. (36).
Avery, Samuel P., 4 E. 38th St., New York, N. Y. (36).
Ayer, Edward Everett, Room 12, The Rookery, Chicago, Ill. (37). H

Baba, Tatui (36). H
Babcock, Geo. H., 30 Cortlandt St., New York, N. Y. (33). D
Bacon, Prof. Chas. A., Observatory Beloit College, Beloit, Wis. (36) A
Bain, James, jr., Toronto, Ontario, Can. (38).
Baker, Richard D., 1414 Arch St., Philadelphia, Pa. (33). E C
Baker, Wm. G., 234 E. 15th St., New York, N. Y. (36).
Balderston, C. Canby, Westtown, Chester Co., Pa. (33). B
Baldwin, Judge Charles C., 1264 Euclid Ave., Cleveland, Ohio (37). H I
Baldwin, Miss Mary A., 28 Fulton St., Newark, N. J. (31). E
Baldwin, Mrs. G. H., 3 Madison Ave., Detroit, Mich. (34). H
Ballard, Harlan H., 50 South St., Pittsfield, Mass. (31). E F
Balliard, Chas., Metropolitan Museum of Art, New York, N. Y. (36).
Banes, Charles H., 2021 Spring Garden St., Philadelphia, Pa. (31). D
Bangs, Lemuel Bolton, M.D., 127 E. 34th St., New York, N. Y. (36).
Barber, D. H., Marion, Iowa (37).
Barclay, Robert, A.M., M.D., 3211 Lucas Ave., St. Louis, Mo. (30).
Bardeen, Francis L., M.D., Box 76, Onondaga Hill, N. Y. (32). C F B
Barge, B. F., Mauch Chunk, Pa. (33).
Barker, Mrs. Martha M., 26 Eleventh St., Lowell, Mass. (31). E H
Barnum, Miss Charlotte C., 144 Humphrey St., New Haven, Conn. (36). A
Bartlett, John W., M.D., 149 W. 94th St., New York, N. Y. (36).

Bartley, Elias H., M.D., 21 Lafayette Ave., Brooklyn, N. Y. (33). C
Bates, Prof. Clinton Owen, Cedar Rapids, Iowa (38).
Bates, Wm. W., 31 Exchange Building, Buffalo, N. Y. (38).
Battershall, Jesse Park, 402 Washington St., New York, N. Y. (36).
Batterson, J. G., Hartford, Conn. (23).
Baur, George, New Haven, Conn. (36).
Baxter, James N., 18 Fulton St., Brooklyn, N. Y. (36).
Baxter, Sylvester, office of the Herald, Boston, Mass. (36). H
Beach, William H., Madison, Wis. (21). E B
Bean, Thos. E., Box 441, Galena, Ill. (28). F
Beardslee, H. C., 801 Wilson Ave., Cleveland, Ohio (37). F
Bechdolt, Adolphus F., Supt. City Schools, Mankato, Minn. (32). E B F
Becker, Dr. Geo. F., U. S. Geol. Survey, San Francisco, Cal. (36). E
Bell, C. M., M.D., 320 Fifth Ave., New York, N. Y. (36).
Benjamin, E. B., 6 Barclay St., New York, N. Y. (19). B C
Benns, Chas. P., Schenectady, N. Y. (38). D
Beveridge, David, 145 Griswold St., Detroit, Mich. (33). I
Bien, Julius, 139 Duane St., New York, N. Y. (34). E H
Bigelow, Otis, 605 7th St., Washington, D. C. (30). H F
Bigelow, Robert P., Washington, D. C. (32). F E
Bingham, Mrs. Martha A., Hotel Brunswick, Kansas City, Mo. (32).
Birdsall, Miss Louise W., 105 E. 37th St., New York, N. Y. (37). F E
Birge, Charles P., Keokuk, Iowa (29). E
Bishop, Heber R., Mills Building, New York, N. Y. (36).
Bixby, Wm. H., Wilmington, N. C. (34). D
Blackstock, Rev. W. S., 20 Homewood Ave., Toronto, Ont., Can. (38). E
Blackwell, Mrs. A. B., Elizabeth, N. J. (30). F C B
Blake, L. I., Hyde Park, Mass. (36).
Blakslee, Prof. T. M., North Des Moines, Iowa (31). A
Blatchford, Eliphalet W., 375 La Salle Ave., Chicago, Ill. (17). F
Bleile, Albert M., M.D., 342 S. Fourth St., Columbus, Ohio (37) F
Blish, W. G., Niles, Mich. (33). B D
Blount, Henry F., University Park, Washington, D. C. (32). I B
Blount, Mrs. Lucia E,, Univ. Park, Washington, D. C. (34). H I
Blue, Archibald, Ass't Minister of Agric., Toronto, Can. (35). I
Boardman, William Dorr, 38 Kenilworth St., Roxbury, Mass. (38). E
Bohannan, R. W., University of Virginia, Va. (36).
Bolton, Prof. John, 49 Huntington St., Cleveland, Ohio (37).
Booraem, J. V. V., 204 Lincoln Place, Brooklyn, N. Y. (36).
Booth, Miss Mary A., Longmeadow, Mass. (34). F I
Booth, Samuel C., Longmeadow, Mass. (34). E I
Bothwell, Geo. W., M.A., Oakland, Cal. (36).
Bourland, Addison M., M.D., Van Buren, Ark. (29). C E F
Boustead, W. E., Toronto, Ontario, Can. (38).
Bowers, Miss Virginia K., 61 Taylor St., Newport, Ky. (27). F H B C
Bowman, Chas. G., Lt. U. S. N., Naval Acad., Annapolis, Md. (38).
Bowser, Mrs. Anna C., 328 Third St., Louisville, Ky. (33). H

Boyer, Jerome L., Sup't Chestnut Hill Iron Ore Co., Reading, Pa. (35). D
Brackett, Richard N., Chemist of the Geological Survey of Arkansas, Little Rock, Ark. (37). C E
Bradford, Royal B., Commander U. S. N., care of Navy Department, Washington, D. C. (31). B D
Braid, James W., Nashville, Tenn. (33).
Bray, Prof. C. D., College Hill, Mass. (29). D B
Brayton, Miss Sarah H., M.D., Evanston, Ill. (33).
Breckinridge, S. M., P. O. Box 346, St. Louis, Mo. (27).
Brice, Judge Albert G., 19 Camp St., New Orleans, La. (32). H
Brill, Prof. Charles C., Northfield, Vt. (36). F
Bristol, Wm. H., Stevens Institute, Hoboken, N. J. (36). A B D
Bromfield, Rev. Edw. T., Glenbrook, Fairfield Co., Conn. (33). F H
Brooke, Dr. Emma W., 15th and Chestnut Sts., Phila., Pa. (33). C E
Brooks, Prof. Wm. P., Amherst, Mass. (33). C F
Broomall, Hon. John M., Media, Delaware Co., Pa. (23). A
Brown, Albert P., Ph.D., 501 Federal St., Camden, N. J. (33). F C
Brown, Fred. G., Fort Ann, Washington Co., N. Y. (31). C E
Brown, Henry A., Saxonville, Mass. (33). I
Brown, Rev. Henry M., East Aurora, Erie Co., N. Y. (35). F C
Brown, Jonathan, 390 Broadway, Somerville, Mass. (29).
Brown, Paul Taylor, 2206 Green St., Philadelphia, Pa. (33). E
Brownell, Silas B., 71 Wall St., New York, N. Y. (36).
Brownell, Prof. Walter A., 905 Univ. Ave., Syracuse, N. Y. (30). E B C
Bryce, Peter H., M.D., Toronto, Ontario, Can. (33).
Buckingham, Chas. L., 195 Broadway, New York, N. Y. (28).
Buffum, Miss Fannie A., Linden, Mass. (29). E C
Bulloch, Walter H., 99 W. Monroe St., Chicago, Ill. (30). F
Burchard, Wm. M., M.D., Uncasville, Conn. (33) B
Burke, William, U. S. Patent Office, Washington, D. C. (28).
Burman, W. A., Winnepeg, Manitoba (33).
Burns, Prof. James A., Box 206, Atlanta, Ga. (32). C E I
Burr, Mrs. Laura E., Commercial Hotel, Lansing, Mich. (34). B
Burwell, Arthur W., 194 Lincoln Ave., Cleveland, Ohio (37).
Bush, Rev. Stephen, D.D., Waterford, N. Y. (19). E H
Byrd, Mary E., Box 110, Lawrence, Kan. (34). A

Cabot, John W., Bellaire Nail Works, Bellaire, Belmont Co., Ohio (35). D
Calder, Edwin E., 15 Board of Trade Building, Providence, R. I. (29). C
Caldwell, Wm. H., State College, Centre Co., Pa. (37). I F
Calkins, Dr. Marshall, Springfield, Mass. (29).
Campbell, Jos. Addison, Queen Lane, Falls of Schuylkill P. O., Philadelphia, Pa. (33).
Campbell, Wm. A., M.D., Ann Arbor, Mich. (34). F B
Campbell, William Wallace, University of Michigan, Ann Arbor, Mich. (33). A
Capen, Miss Bessie T., Northampton, Mass. (23). C

Cardeza, John M., M.D., Claymont, Del. (88). E
Caron, C. K., Louisville, Ky. (30). E C
Carpenter, Geo. O., jr., care of St. Louis Lead and Oil Co., St. Louis, Mo. (29).
Carroll, Alfred L., M.D., New Brighton, Staten Island, N. Y. (36). F
Carrington, Col. Henry B., U. S. A., Hyde Park, Mass. (20).
Carter, Calvin, C.E., Brookville, Ind. (37) D
CARTER, JAMES C., 277 Lexington Ave., New York, N. Y. (36).
Carter, John E., Knox and Coulter Sts., Germantown, Pa. (33). B H
Cary, Albert A., 234 W. 29th St., New York, N. Y. (36). D
Casey, Thomas L., Room 79, Army Building, 39 Whitehall St., New York, N. Y. (38). F
Catlin, Charles A., 133 Hope St., Providence, R. I. (33). C
Causey, Francis F., Hampton, Va. (36) I
Chadbourn, Erlon R., Lewiston, Me. (29).
Chahoon, Mrs. Mary D., 134 S. Fourth St., Philadelphia, Pa. (33).
Chaffee, Prof. Arthur B., Seymour, Ind. (37)
Chamberlain, Alexander F., 34 Arthur St., Toronto, Ontario, Can. (38). H
Champlin, John D., jr., 745 Broadway, New York, N. Y. (36).
Chandler, John R., Ph.D., U. S. Vice Consul General, Guatemala, Central America (36) F H
Chaplin, Prof. Winfield S., Harvard Univ., Cambridge, Mass. (37). D A
Charbonnier, Prof. L. H., University of Georgia, Athens, Ga. (26). A B D
Chase, Rev. E. B., Lyons, Iowa (37).
Chase, Mrs. Mariné J., 1622 Locust St., Philadelphia, Pa. (31). E F
Chase, R. Stuart, 53 Summer St., Haverhill, Mass. (18). F
Chatfield, A. F., Albany, N. Y. (29).
Chester, Commander Colby M., U. S. N., care Navy Dept. Washington, D C. (28). E
Childe, John Healey, 12 Brimmer St., Boston, Mass. (31).
Childs, Wm. Addison, M.A., National Club, Toronto, Ont., Can. (38). C H D
Christie, James, Pencoyd, Pa. (33). D
Chrystie, Wm. F., Hastings-on-Hudson, New York, N. Y. (36).
Church, Royal Tyler, Turin, Lewis Co., N. Y. (38). D F
Church, W. C., 240 Broadway, New York, N. Y. (36).
Claghorn, Clarence R., M.E., P. O. Box 806, Birmingham, Ala. (37). E
Clapp, Geo. H., 98 Fourth Ave., Pittsburgh, Pa. (33). H C
Clark, Alex S., Westfield, N. J. (33).
Clark, John S., 7 Park St., Boston, Mass. (31). I B C
Clark, Wm. Brewster, M.D., 50 E. 31st St., New York, N. Y. (33). F C
Clark, William Bullock, Ph.D., Johns Hopkins Univ., Baltimore, Md. (37). E
Clarke, Charles S., 130 Moss St., Peoria, Ill. (34).
Clarke, Robert, Cincinnati, Ohio (30). H
Clement, Arthur G., Sup't N. Y. State Inst. for the Blind, Batavia, N. Y. (38). E

Clendenin, Wm. W., Box 722, Columbia, Mo. (37).
Coakley, George W., LL.D., Hempstead, L. I. (29). A B D
COE, HENRY W., M.D., Mandan, Dakota (32). H F
Coffin, Amory, Phœnixville, Chester Co., Pa. (31). D
Cogswell, W. B., Syracuse, N. Y. (33). D
Coit, J. Milner, Ph.D., Saint Paul's School, Concord, N. H. (33). B C E
COLBURN, RICHARD T., Elizabeth, N. J. (31). I
Coles, D. S., A.M, M.D., Wakefield, Mass. (35). F
Colle, Edw. M., East Orange, N. J. (30). E I
Collin, Prof. Alonzo, Cornell College, Mount Vernon, Iowa (21). B C
Collin, Rev. Henry P., Coldwater, Mich. (37). F
Collins, Miss Anna E. (36).
Collins, Miss Fanny W., Greenwich, Conn. (36).
Collins, Prof. Jos. V., Miami Univ., Oxford, Ohio (37). A
Colman, Henry, M.D., 64 Nahant St., Lynn, Mass. (25). F
Colonna, B. A., U. S. C. and G. Survey, Washington, D. C. (37). E
Comstock, Dr. T. Griswold, 507 North 14th St., St. Louis, Mo. (29). F H
Conant, Miss E. Ida, 42 West 48th St., New York, N. Y. (33). H I F
Conklin, W. A., Director Central Park Menagerie, New York, N. Y. (29). F
Cook, Dr. Charles D., 183 Pacific St., Brooklyn, N. Y. (25).
Cooke, Martin W., Rochester, N. Y. (36).
Coon, Henry C., M.D., Alfred Centre, N. Y. (29). B C F
Cope, Thos. P., Awbury, Germantown, Pa. (33). I
Coville, Frederick V., Oxford, Chenango Co., N. Y. (35). F
Cowell, Jno. F., Buffalo, N. Y. (35).
Cowles, Alfred H., "Daily Leader" Building, Cleveland, Ohio (37). B C
Crafts, Robert H., 2329 So. 6th St., Minneapolis, Minn. (32). I B
Cragin, Francis W., Washburn College, Topeka, Kan. (29). F E H
Craig, Thomas, Tompkinsville, Staten Island, N. Y. (36). F
Craighill, Col. Wm. P., 1734 St. Paul St., Baltimore, Md. (37) D
Creelman, G. C., B. S. A., Agricultural College, Miss. (38) F
Croffut, William A., U. S. Geol. Survey, Washington, D. C. (38). H I
Crosier, Dr. Edward S., New Albany, Ind. (29). F
CROWELL, A. F., Woods Holl, Mass. (30). C
Crozier, A. A., Agric. College, Ames, Iowa (36).
Cruikshank, James, LL.D., 206 So. Oxford St., Brooklyn, N. Y. (36).
Crump, M. H., Col. Commanding 3d Reg. K. S. G., Bowling Green, Ky. (29). E
Culin, Stewart, 127 South Front St., Philadelphia, Pa. (33). H
Cummings, John, Woburn, Mass. (18). F
Cummins, W. F., Dallas, Texas (37) E
Cunningham, Francis A., 1613 Wallace St., Philadelphia, Pa. (33). D E B
Cunningham, Prof. Susan J., Swarthmore College, Swarthmore, Pa. (38). A
Cuntz, Johannes H., 137 Hudson St., Hoboken, N. J. (36).
Currier, John McNab, M.D., Newport, Vt. (28). H F E
Curtis, Edw., M.D., 120 Broadway, New York, N. Y. (36).

Curtis, Geo. Wm., West New Brighton, Staten Island, N. Y. (36).
Cutler, Dr. Andrew S., Kankakee, Ill. (32). I E

Da Costa, Chas. M., 4 W. 33d St., New York, N. Y. (36).
Daly, Hon. Charles P., 84 Clinton Place, New York, N. Y. (36).
Damon, Wm. E. (34). F
Dana, S. B., P. O. Box 1395, Boston, Mass. (36).
Dancy, Frank B., N. C. Agric. Experiment Station, Raleigh, N. C. (33). C
Daniel, John, Vanderbilt Univ., Nashville, Tenn. (38). B
Daniels, Edw., Washington, D. C. (32)
Darling, Thomas, 99 Drummond St., Montreal, P. Q., Can. (36). I
Davis, Andrew McFarland, B.S., 10 Appleton St., Cambridge, Mass. (35). H
Davis, Ellery Williams, Senate St., Columbia, S. C. (36).
Davis, J. J., M.D., 1119 College Ave., Racine, Wis. (31). F
Davison, John M., jr., 60 Oxford St., Rochester, N. Y. (38). C
Dawson, Geo. M., D.S.C., F.G.S., Ottawa, Ontario, Can. (38).
*Day, Albert, 251 Broadway, New York, N. Y. (36). E
Day, Austin G., 16 Dey St., New York, N. Y. (29).
Day, L. W., Ph.D., Cleveland, Ohio (37).
Dean, Seth, Glenwood, Iowa (34). D
DeForest, Henry S., Pres. Talladega College, Talladega, Ala. (32). H I
Degni, Rev. J. M., Woodstock College, Woodstock, Howard Co., Md. (33). B A
Dennis, Miss Mary B., Curator of Museum, Flushing High School, Flushing, N. Y. (37) E
Denton, John M., London, Ontario, Can. (31).
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Sargent, Erle Hoxsie, Orchard Lake, Michigan (37). F

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Sessions, Francis C., Columbus, Ohio (34).
Seymour, Arthur Bliss, Cambridge, Mass. (36). F
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SHEAFER, A. W., Pottsville, Pa. (28).
Sheafer, Walter S., Pottsville, Pa. (25).
Shelton, Prof. Edward M., Manhattan, Kansas (32). F
Shepard, William A., Saratoga Springs, N. Y. (28).
Sherman, Prof. F. A., Hanover, N. H. (29). A B
Shultz, Charles S., Hoboken, N. J. (31). F
Shuttleworth, Edward B., Toronto, Ontario, Can. (38). C
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Slade, Wm. S., Buffalo, N. Y. (35).
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Smith, Benj. G., Cambridge, Mass. (29). I
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Smith, De Cost, Skaneateles, N. Y. (38). H
Smith, E. Reuel, Skaneateles, N. Y. (38).
Smith, Prof. Edgar F., Univ. of Penna., Philadelphia, Pa. (33). C
Smith, Erwin F., Dep't of Agric., Washington, D. C. (34). F
Smith, Geo. Gregory, St. Albans, Vt. (36).
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Smith, Prof. Herbert S. S., Coll. of New Jersey, Princeton, N. J. (29). D

Smith, Mrs. J. Lawrence, Louisville, Ky. (26).
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Smyth, C. H., jr., Clinton, N. Y. (38).
Smyth, Prof. Jas. D., Burlington, Iowa (28). I
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Spencer, Geo. S., St. Cloud, Minn. (32). E
Spencer, J. Selden, Tarrytown-on-Hudson, N. Y. (36).
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Sperry, Chas., Port Washington, L. I. (33). D A B C E I
Sperry, Prof. Lyman B., Bellevue, Huron Co., Ohio (32). E
Speyers, Clarence L., Columbia, Mo. (36). C
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SPRAGUE, C. H., Malden, Mass. (29).
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Stam, Colin F., Chestertown, Md. (33). C F
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Stewart, Francis L., Murrysville, Pa. (38). F C
Stine, Prof. W. M., Ohio Univ., Athens, Ohio (37). A C
Stokes, Henry Newlin, Ph.D., U. S. Geol. Surv., Washington, D. C. (38). C E
Stoller, Prof. James H., Union College, Schenectady, N. Y. (36). E F
Stone, Mrs. Alfred, Providence, R. I. (31).
Stone, Lincoln R., M.D., Newton, Mass. (31).
Stone, Miss Mary H., Salem, Mass. (25).
Stowell, John, 48 Main St., Charlestown, Mass. (21).
Street, Charles Stuart, 38 Kenilworth St.. Roxbury, Mass. (38). E C
Stuart, Dr. William Theophilus, 197 Spadina Ave., Toronto, Ontario, Can. (38). B C E F

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Taft, Mrs. Charles E., care Census Bureau, Washington, D. C. (37). B
Taft, Elihu B., Burlington, Vt. (36). H
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Talbutt, John H., Lexington, Ky. (38).
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Thomson, Prof. Harvey, Hastings, Neb. (35). F
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Thruston, R. C. Ballard, Louisville, Ky. (36). E
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Turner, Henry Ward, Valley Springs, Cal. (34). E
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Vail, Prof. Hugh D., Santa Barbara, Cal. (18).
Valentine, Benj. B., Richmond, Va. (33). H
Valentine, Edw. P., Richmond, Va. (33). H
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Wardwell, George J., Rutland, Vt. (20). D E
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Webb, Miss Sarah E. (33). H F
Webster. F. M., La Fayette, Ind. (35).
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Willet, Joseph Edgerton, Macon, Ga. (36). E
Willetts, Joseph C., Skaneateles, N. Y. (29). E F H
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Willmott, Arthur B., Antioch College, Yellow Springs, Ohio (38).
Willson, Robert W., Cambridge, Mass. (30). B A
Wilmot, Thos. J., Commercial Cable Co., Waterville, County Kerry, Ireland (27). B
Wilson, Prof. Edmund B., Bryn Mawr, Pa. (36).
Wilson, James M., Riverton, Ill. (33).
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Winchell, Martin R., 120 Nassau St., New York, N. Y. (36). I
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Winterhalter, A. G., Lt. U. S. N., U. S. Naval Observ., Washington, D. C. (37). A
Wisser, John P., 1st Lieutenant, 1st Artillery, U. S. A., West Point, N. Y. (33). C
Withers, Prof. W. A., Agric. Mechanical College, Raleigh, N. C. (33). C
Witthaus, Dr. R. A., 410 E. 26th St., New York, N. Y. (35).
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Wolcott, Mrs. Henrietta L. T., Dedham, Mass. (29).
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Wood, Harry A., M.D., State Insane Asylum, Buffalo, N. Y. (35).
Wood, Joseph S., Mount Vernon, Westchester Co., N. Y. (36).
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Woodford, Prof. A. B., Indiana Univ., Bloomington, Ind. (36). I
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Wright, Prof. R. Ramsey, Toronto, Ontario, Can. (38). F
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Würtele, Miss Minnie, Acton Vale, P. Q., Can. (32). H
Wyman, Walter Channing, 158 Dearborn St., Chicago, Ill. (34). H

Youmans, Mrs. Celia G., Mount Vernon, N. Y. (36).
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Ziwet, Alexander, Univ. of Michigan, Ann Arbor, Mich. (38). A

[1232 Patrons and Members.]

Note.—The omission of an address in the foregoing list indicates that letters directed to that last printed were returned as uncalled for. Information of the present address of the members so indicated is requested by the Permanent Secretary.

HONORARY FELLOWS.[1]

ROGERS, WILLIAM B., Boston, Mass. (1). 1881. (Born Dec. 7, 1804. Died May 30, 1882.) **B E**

CHEVREUL, MICHEL EUGÈNE, Paris, France (35). 1886. (Born Aug. 31, 1786. Died April 9, 1889.)

GENTH, DR. F. A., 3937 Locust St., Philadelphia, Pa. (24). 1875. 1888. **C E**

FELLOWS.[2]

Abbe, Professor Cleveland, Army Signal Office, Washington, D. C. (16). 1874. **B A**

Abbott, Dr. Chas. C., Trenton, N. J. (29). 1883. **F H**

Adams, Frank Dawson, 141 Rideau St., Ottawa, Ontario, Can. (29). 1885.

Alden, Prof. Geo. I., Worcester, Mass. (33). 1885. **D**

Alexander, John S., Texas Nat'l Bank, San Antonio, Texas (20). 1874. **B C D**

Allen, Dr. Harrison, 117 S. 20th St., Philadelphia, Pa. (29). 1882. **F**

Allen, Joel A., American Museum of Natural History, Central Park, New York (18). 1875. **F**

Allen, Dr. T. F., 10 E. 36th St., New York, N. Y. (35). 1887. **F**

Alvord, Major Henry E., Agricultural College, Md. (29). 1882. **I**

Ammen, Daniel, Rear Admiral U. S. Navy, Beltsville, Md. (26). 1881. **E**

Anderson, Dr. Joseph, Waterbury, Conn. (29). 1883. **H**

Anthony, Prof. Wm. A., Manchester, Conn. (28). 1880. **B**

Arey, Albert L., Free Academy, Rochester, N. Y. (35).

Arthur, J. C., La Fayette, Ind. (21). 1883. **F**

Ashburner, Charles A., Penn Building, Pittsburgh, Pa. (31). 1883. **E**

Atkinson, Edward, 31 Milk St., Boston, Mass. (29). 1881. **I D**

Atwater, Prof. W. O., Wesleyan Univ., Middletown, Conn. (29). 1882. **C**

Auchincloss, Wm. S., 209 Church St., Philadelphia, Pa. (29). 1886. **D A**

Avery, Elroy M., Ph.D., Woodland Hills Ave., Cleveland, Ohio (37). 1889. **B**

Ayers, Howard (34). 1886. **F**

Ayres, Prof. Brown, Tulane University, New Orleans, La. (31). 1885. **B**

Babbitt, Miss Franc E., Lock Box 1284, Coldwater, Mich. (32). 1887. **H I**

Babcock, S. Moulton, Madison, Wis. (33). 1885. **C**

Bailey, E. H. S., Lawrence, Douglas Co., Kan. (25). 1889. **C E**

Bailey, Prof. Liberty H., Ithaca, N. Y. (34). 1887. **F**

[1] See ARTICLE VI of the Constitution. [2] See ARTICLE IV of the Constitution.

*** The number in parenthesis indicates the meeting at which the member joined the Association; the date following is the year when made a Fellow; the black letters at end of line are those of the sections to which the fellow belongs.

When the name is given in small capitals, it designates that the Fellow is also a Life Member, and is entitled to the Annual Volume of Proceedings.

Bailey, Prof. Loring W., University of Fredericton, N. B. (18). 1875.
Bailey, Prof. W. W., Brown University, Providence, R. I. (18). 1874. **F**
Baker, Frank, M.D., 1315 Corcoran St., Washington, D. C. (31). 1886. **F H**
Baker, Marcus, U. S. Geological Survey, Washington, D. C. (30). 1882. **A**
BARKER, PROF. G. F., Univ. of Penn., Philadelphia, Pa. (13). 1875. **B C**
Barnard, Edward E., Lick Observ., San José, Cal. (26). 1883. **A**
Barnes, Prof. Chas. R., Madison, Wis. (33). 1885. **F**
Bartlett, Prof. Edwin J., Dartmouth College, Hanover, N. H. (28). 1883. **C**
Bartlett, John R., Commander U. S. N., Navy Dep't, Washington, D. C. (30). 1882. **E B**
Barus, Carl, Ph.D., U. S. Geol. Survey, Washington, D. C. (33). 1887. **B**
Bassett, Homer F., Waterbury, Conn. (23). 1874. **F**
Batchelder, John M., 3 Divinity Avenue, Cambridge, Mass. (8). 1875. **B D I**
Bates, Henry Hobart, U. S. Patent Office, Washington, D. C. (33). 1887. **B A C D**
Battle, Herbert B., Ph.D., Director N. C. Agric. Exper. Station, Raleigh, N. C. (33). 1889. **C**
Bausch, Edward, Rochester, N. Y. (26). 1883. **A B C F**
Baylor, James B., U. S. Coast and Geodetic Survey Office, Washington, D. C. (33). 1888. **A**
Beal, Prof. Wm. James, Agricultural College, Ingham Co., Mich. (24). 1880. **F**
Beardsley, Prof. Arthur, Swarthmore College, Swarthmore, Del. Co., Pa. (33). 1885. **D**
Beauchamp, Rev. Wm. M., Baldwinsville, N. Y. (34). 1886. **H**
Bell, Dr. Alex. Graham, Scott Circle, 1500 Rhode Island Ave., Washington, D. C. (26). 1879. **B H I**
Bell, Alex. Melville, 1525 35th St., Washington, D. C. (31). 1885. **H**
Bell, Robert, LL.D., Ass't Director Geological Survey, Ottawa, Ontario, Can. (38). 1889. **E F**
Beman, Wooster W., 19 So. 5th St., Ann Arbor, Mich. (34). 1886. **A**
Benjamin, Marcus, 15 W. 121st St., New York, N. Y. (27). 1887. **C**
Benjamin, Rev. Raphael, M.A., 1384 Lexington Ave., New York, N. Y. (34). 1887. **F A B D E H I**
Bennett, Prof. Wm. Z., Wooster, Wayne Co., Ohio (33). 1889. **C**
Bessey, Prof. Charles E., Univ. of Nebraska, Lincoln, Neb. (21). 1880. **F**
Bethune, Rev. C. J. S., Trinity College School, Pt. Hope, Ont., Can. (18). 1875. **F**
Beyer, Dr. Henry G., U. S. N., U. S. National Museum, Washington, D. C. (31). 1884. **F**
Bickmore, Prof. Albert S., American Museum of Natural History, 8th Ave. and 77th St., Central Park, New York, N. Y. (17). 1880. **H**
Bigelow, Prof. Frank H., Racine, Wis. (36) 1888. A

Billings, John S., Surgeon U. S. A., Surg. General's Office, Washington, D. C. (32). 1883. F H

Blackham, George E., M.D., Dunkirk, N. Y. (25). 1883. F

Blake, Clarence J., M.D., 226 Marlborough St., Boston, Mass. (24). 1877. B F

Blake, Prof. Eli W., Brown Univ., Providence, R. I. (15). 1874. B

Blake, Francis, Auburndale, Mass. (28). 1874. B A

Blake, Francis C., Mansfield Valley P. O., Allegheny Co., Pa. (29). 1889. C B D

Boardman, Mrs. William D., 38 Kenilworth St., Roxbury, Mass. (28). 1885. E H

Boas, Dr. Franz, 196 Third Ave., New York, N. Y. (36) 1888. H

Boerner, Chas. G., Vevay, Switzerland Co., Ind. (29). 1886. A B E

Bolton, Dr. H. Carrington, University Club, New York, N. Y. (17). 1875. C

Bond, Geo. M., care of The Pratt & Whitney Co., Hartford, Conn. (33). 1885. D

Borden, Spencer, Fall River, Mass. (29). 1882. B C I

Boss, Prof. Lewis, Director Dudley Observ., Albany, N. Y. (26). 1878.

Bourke, John G., Capt. 3d Cavalry, U. S. A., War Dept., Washington, D. C. (33). 1885. H

Bouvé, Thos. T., Boston Soc. Nat. Hist., Boston, Mass. (1). 1875. E

Bowditch, Prof. H. P., Jamaica Plain, Mass. (28). 1880. F B H

Bowditch, Henry I., M.D., 113 Boylston St., Boston, Mass. (2). 1875. F H

Bowser, Prof. E. A., Rutgers College, New Brunswick, N. J. (28). 1881.

Brace, DeWitt B., Lincoln, Neb. (35). 1887. B

Brackett, Prof. C. F., College of New Jersey, Princeton, N. J. (19). 1875. B

Brackett, Solomon H., St. Johnsbury, Vt. (29). 1884. B A

Branner, John C., Director of the Geological Survey of Arkansas, Little Rock, Ark. (34). 1886. E F

Bransford, John Francis, Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (36) 1888. H I

Brashear, Jno. A., Allegheny, Pa. (33). 1885. A B D

Brewer, Prof. Wm. H., New Haven, Conn. (20). 1875. E F I

Brewster, William, 61 Sparks St., Cambridge, Mass. (29). 1884. F

Brinton, D. G., M.D., 2014 Chestnut St., Philadelphia, Pa. (33). 1885. H

Britton, N. L., Columbia College, New York, N. Y. (29). 1882. F E

Broadhead, Garland Carr, Pleasant Hill, Cass Co., Mo. (27). 1879. E

Brooks, Wm. R., Box 714, Geneva, N. Y. (35). 1886. A B D G

Bross, Hon. Wm., Tribune Office, Chicago, Ill. (7). 1874. E H

Brown, Robert, care of Yale College Observatory, New Haven, Conn. (11). 1874.

Brown, Mrs. Robert, New Haven, Conn. (17). 1874.

Brühl, Gustav, cor. John and Hopkins Sts., Cincinnati, Ohio (28). 1886. H

Brush, Charles F., Brush Electric Light Co., Cleveland, Ohio (35). 1886. B

Brush, Prof. George J., Yale College, New Haven, Conn. (4). 1874. C E

Bryce, George, LL.D., Manitoba College, Winnipeg, Manitoba (38). 1889. H

Buckhout, W. A., State College, Centre Co., Pa. (20). 1881. **F**
Burgess, Dr. Thomas J. W., Ass't Sup't Asylum, Hamilton, Ontario, Can. (38). 1889. **F**
Burr, Prof. William H., Phoenixville, Chester Co., Pa. (31). 1883.
Burrill, Prof. T. J., Univ. of Illinois, Champaign, Ill. (29). 1882. **F**
Butler, A. W., Brookville, Franklin Co., Ind. (30). 1885. **F H**

Caldwell, Prof. Geo. C., Cornell University, Ithaca, N. Y. (23). 1875. **C**
Calvin, Prof. Samuel, State Univ. of Iowa, Iowa City, Iowa (37). 1889. **B E**
Campbell, Douglas H., 91 Alfred St., Detroit, Mich. (34) 1888. **F**
Campbell, Edw. D. (34). 1887. **C**
Canby, William M., 1101 Delaware Avenue, Wilmington, Del. (17). 1878. **F**
Carhart, Prof. Henry S., University of Michigan, Ann Arbor, Mich. (29) 1881. **B**
Carmichael, Prof. Henry, 7 Broad St., Boston, Mass. (21). 1875. **C**
Carpenter, Louis G., Agricultural College, Fort Collins, Col. (32). 1889. **A B**
Carpenter, Capt. W. L., U. S. A., Dunkirk, N. Y. (24). 1877. **F E**
Carpmael, Charles, Director of Magnetic Observatory, Toronto, Ontario, Can. (31). 1883. **B**
Carr, Lucien, Peabody Museum Archæology and Ethnology, Cambridge, Mass. (25). 1877. **H**
Case, Col. Theo. S., Kansas City, Mo. (27). 1883. **H B**
Chamberlin, T. C., Madison, Wis. (21). 1877. **E B F H**
Chandler, Prof. C. F., School of Mines, Columbia Coll., East 49th St. cor. 4th Ave., New York, N. Y. (19). 1875. **C**
Chandler, Prof. Charles Henry, Ripon, Wis. (28). 1883. **A B**
Chandler, Seth C., jr., 16 Cragie St., Cambridge, Mass. (29). 1882. **A**
Chandler, Prof. W. H., South Bethlehem, Pa. (19). 1874. **C**
Chanute, O., Kansas City, Mo. (17). 1877. **D I**
Chapin, Dr. J. H., Meriden, Conn. (33). 1886. **E H**
Chester, Prof. Albert H., Hamilton College, Clinton, N. Y. (29). 1882. **C F**
Chester, Prof. Fred'k D., Del. State Coll., Newark, Del. (33). 1887. **E**
Chickering, Prof. J. W., jr., Deaf Mute College, Washington, D. C. (22). 1877. **F I**
Chute, Horatio N., Ann Arbor, Mich. (34). 1889. **B C A**
Clapp, Miss Cornelia M., Mt. Holyoke Seminary, South Hadley, Mass. (31). 1883. **F**
Clark, Alvan G., Cambridgeport, Mass. (28). 1880. **A B**
Clark, Prof. John E., Mathematics, Yale College, New Haven, Conn. (17). 1875. **A**
Clarke, Prof. F. W., U. S. Geological Survey, Washington, D. C. (18). 1874. **C**
Claypole, Prof. Edw. W., Buchtel Coll., Akron, Ohio (30). 1882. **E F**
Clayton, H. Helm, Readville, Mass. (34). 1887. **B**

Cloud, John W., Buffalo, N. Y. (28). 1886. A B D

Coffin, Prof. Selden J., Lafayette College, Easton, Pa. (22). 1874. A I

Collett, Prof. John, Indianapolis, Ind. (17). 1874. E

Collingwood, Francis, Elizabeth, N. J. (36). 1888. D

Colvin, Verplanck, Supt. N. Y. State Adirondack Survey, Albany, N. Y. (28). 1880. E

Comstock, Prof. Geo. C., Washburn Observ., Univ. of Wisconsin, Madison, Wis. (34). 1887. A

Comstock, J. Henry, Cornell Univ., Ithaca, N. Y. (28). 1882. F

Comstock, Milton L., Knox College, Galesburg, Ill. (21). 1874. A

Comstock, Prof. Theo. B., Geol. Survey of Texas, Austin, Texas. (24). 1877. D E B

Cook, Prof. A. J., Agricultural College, Mich. (24). 1880. F

Cook, Chas. Sumner, Evanston, Ill. (36). 1889. B

Cooley, Prof. Le Roy C., Vassar College, Poughkeepsie, N. Y. (19). 1880. B C

Cooley, Prof. Mortimer E., Univ. of Michigan, Ann Arbor, Mich. (33). 1885. D

Cope, Prof. Edward D., 2100 Pine St., Philadelphia, Pa. (17). 1875. F E

Corthell, Elmer L., 205 La Salle St., Chicago, Ill. (34). 1886. D

Coulter, Prof. John M., Wabash College, Crawfordsville, Ind. (32). 1884. F

Cox, Prof. Edward T., 18 Cortlandt St., New York, N. Y. (19). 1874. E

Cox, Hon. Jacob D., Gilman Ave., Mt. Auburn, Cincinnati, Ohio (30). 1881. F

Coxe, Eckley B., Drifton, Luzerne Co., Pa. (23). 1879. D E

Crampton, Chas. A., Dept. of Agric., Washington, D. C. (36). 1887. C

Crandall, Prof. A. R., Lexington, Ky. (29). 1883. E F

Crawford, Prof. Morris B., Middletown, Conn. (30). 1889. B

Crocker, Susan E., M.D., Lawrence, Mass. (21). 1874. E F

Crosby, Prof. Wm. O., Boston Society of Natural History, Boston, Mass. (29). 1881. E

Cross, Prof. Chas. R., Mass. Institute Technology, Boston, Mass. (29). 1880. B

Cushing, Henry Platt, 786 Prospect St., Cleveland, Ohio (33). 1888. E

Cutting, Hiram A., M.D., State Geologist, Lunenburgh, Vt. (17). 1874. E F

Dabney, Chas. W., jr., Ph.D., Agricultural Experiment Station, Raleigh, N. C. (30). 1882. C B E

Dall, Mrs. Caroline H., 1630 O St., Washington, D. C. (18). 1874. F H

Dall, William H., Smithsonian Institution, Washington, D. C. (18). 1874. H F

Dana, Edward Salisbury, New Haven, Conn. (23). 1875. B E

Dana, Prof. James D., New Haven, Conn. (1). 1875. E

Davenport, B. F., M.D., 161 Tremont St., Boston, Mass. (29). 1883. C

Davidson, Prof. Geo., U. S. Coast and Geodetic Survey, San Francisco, Cal. (29). 1881. A B D

Davis, Wm. Morris, Cambridge, Mass. (33). 1885. E B

Dawson, Sir William, Principal McGill College, Montreal, Can. (10). 1875. E

Day, David F., Buffalo, N. Y. (35). 1887. F

Day, F. H., M.D., Wauwatosa, Wis. (20). 1874. E H F

Dean, George W., P. O. Box 92, Fall River, Mass. (15). 1874. A

Denton, Prof. James E., Stevens Institute, Hoboken, N. J. (36). 1888. D B A

Dewey, Fred P., Ph.B., 621 F St. N. W., Washington, D. C. (30). 1886. C E

Diller, J. Silas, U. S. Geological Survey, Washington, D. C. (29). 1884. E

Dimmock, George, Cambridge, Mass. (22). 1874. F

Dodge, Charles R., Washington, D. C. (22). 1874.

Dodge, Prof. James A., University of Minnesota, Minneapolis, Minn. (29). 1884. C E

Dodge, J. Richards, Washington, D. C. (31). 1884. I H

Dolbear, A. Emerson, College Hill, Mass. (20). 1880. B

Doolittle, Prof. C. L., South Bethlehem, Pa. (25). 1885. A

Dorsey, Rev. J. Owen, Box 591, Washington, D. C. (31). 1883. H

Douglass, Andrew E., 63 Pine St., New York, N. Y. (31). 1885. H

Dow, Capt. John M., 83 W. 71st St., New York, N. Y. (31). 1884. F H

Draper, Dan'l, Ph. D., Director N. Y. Meteorological Observatory, Central Park, 64th St., Fifth Avenue, New York, N. Y. (29). 1881. B D F A

Drown, Prof. Thos. M., Mass. Institute Technology, Boston, Mass. (29). 1881. C

Du Bois, Prof. Aug. J., New Haven, Conn. (30). 1882. A B D

Du Bois, Patterson, Ass't Editor S.S.T., 1031 Walnut St., Philadelphia, Pa. (33). 1887. H C I

Dudley, Charles B., Altoona, Pa. (23). 1882. C B D

Dudley, P. H., 66½ Pine St., New York, N. Y. (29). 1884.

Dudley, Wm. L., Prof. of Chemistry, Vanderbilt Univ., Nashville, Tenn. (28). 1881. C

Dudley, Prof. Wm. R., Ithaca, N. Y. (29). 1883. F

Dunnington, Prof. F. P., University of Virginia, Va. (26). 1880. C

Dutton, Capt. C. E., U. S. Geol. Surv., Washington, D. C. (23). 1875.

Dwight, Prof. William B., Vassar College, Poughkeepsie, N. Y. (30). 1882. E F

Eastman, Prof. J. R., U. S. Naval Observatory, Washington, D. C. (26). 1879. A

Eaton, Prof. D. G., 55 Pineapple St., Brooklyn, N. Y. (19). 1874. B E

Eaton, Prof. James R., Liberty, Mo. (29). 1885. C B E

Eddy, Prof. H. T., Univ. of Cincinnati, Cincinnati, O. (24). 1875. A B D

Edison, Thos. A., Menlo Park, N. J. (27). 1878. B

Edmands, J. Rayner, Observatory, Cambridge, Mass. (29). 1880.

Egleston, Prof. Thomas, 35 W. Washington Square, New York, N. Y. (27). 1879. **C D E**

Eimbeck, William, U. S. C. and G. S., Washington, D. C. (17). 1874. **A B D**

Elkin, William L., Yale Coll. Observ., New Haven, Conn. (33). 1885. **A**

Elliott, Arthur H., 591 Broadway, care Anthony's Bulletin, New York, N. Y. (23). 1880. **C**

Emerson, Prof. Benjamin K., Amherst, Mass. (19). 1877. **E F**

Emerson, Prof. C. F., Dartmouth Coll., Hanover, N. H. (22). 1874. **B A**

Emerton, James H., 11 St. James Ave., Boston, Mass. (18). 1875. **F**

Emery, Albert H., Stamford, Conn. (29). 1884. **D B**

Emery, Charles E., 22 Cortlandt St., New York, N. Y. (34). 1886. **D B A**

Emmons, S. F., U. S. Geol. Survey, Washington, D. C. (26). 1879. **E**

Engelmann, George J., M.D., 3003 Locust St., St. Louis, Mo. (25). 1875. **F H**

Evans, Asher B., 500 Pine St., Lockport, N. Y. (19). 1874. **A**

Ewing, Thomas, jr., Patent Office, Washington, D. C. (36). 1889. **B**

Eyerman, John, Easton, Pa. (33). 1889. **E C**

Fairbanks, Henry, Ph.D., St. Johnsbury, Vt. (14). 1874. **B D A**

Fairchild, Prof. H. L., University of Rochester, Rochester, N. Y. (28). 1883. **E F**

Fall, Prof. Delos, Albion College, Albion, Mich. (34). 1887. **C**

Fanning, John T., Consulting Eng., Great Northern Railway Building, St. Paul, Minn. (29). 1885. **D**

Farlow, Dr. W. G., 29 Holyoke House, Cambridge, Mass. (20). 1875. **F**

Farmer, Moses G., Eliot, Me. (9). 1875.

Farquhar, Henry, Coast Survey Office, Washington, D. C. (33). 1886. **A I F B**

Fernald, Prof. Charles H., Amherst, Mass. (22). 1881. **F E**

Fernald, Prof. M. C., State Agric. College, Orono, Me. (22). 1883. **B A**

Fernow, Bernhard E., Chief of Forestry Division, Dep't of Agriculture, Washington, D. C. (31). 1887. **F I**

Ferrel, Wm., 1641 Broadway, Kansas City, Mo. (11). 1875. **A B**

Fine, Prof. Henry B., Coll. of New Jersey, Princeton, N. J. (35). 1887. **A**

Firmstone, F., Easton, Pa. (33). 1887. **D**

Fitch, Edward H., Jefferson, Ashtabula Co., Ohio (11). 1874. **I E**

Fletcher, Miss Alice C., care Peabody Museum, Cambridge, Mass. (29). 1883. **H**

Fletcher, James, Dominion Entomologist, Ottawa, Ontario, Can. (31). 1883. **F**

Fletcher, Dr. Robert, Army Medical Museum, Washington, D. C. (29). 1881. **F H**

Flint, Albert S., Washburn Observ., Madison, Wis. (30). 1887. **A**

Flint, James M., Surgeon U. S. N., Smithsonian Institution, Washington, D. C. (28). 1882. **F**

Floyd, Richard S., 120 Sutter St., San Francisco, Cal. (34). 1889. **A**

Foote, Dr. A. E., 1223 Belmont Ave., Philadelphia, Pa. (21). 1874. E C
Foye, Prof. J. C., Lawrence Univ., Appleton, Wis. (29). 1884. C B
FRAZER, DR. PERSIFOR, 917 Clinton St., Philadelphia, Pa. (24). 1879. E C
Frazier, Prof. B. W., The Lehigh University, Bethlehem, Pa. (24). 1882. E C
Frear, Wm., State College, Centre Co., Pa. (33). 1886. C
French, Prof. Thomas, jr., Ridgeway Ave., Avondale, Cincinnati, Ohio (30). 1883. B
Frisby, Prof. Edgar, U. S. N. Observ., Washington, D. C. (28). 1880. A
Fuller, Andrew S., Ridgewood, Bergen Co., N. J. (24). 1882. F
Fulton, Prof. Robert B., University, Miss. (21). 1887. B A

Gaffield, Thomas, 54 Allen St., Boston, Mass. (29). 1889. C B
Gage, Simon Henry, Ithaca, N. Y. (28). 1881. F
Galbraith, Prof. John, Toronto, Ontario, Can. (38). 1889.
Gannett, Henry, U. S. Geological Survey, Washington, D. C. (33). 1884. E I A
Gardiner, James T., 21 Elk St., Albany, N. Y. (25). 1879. E
Garland, Rev. Dr. L. C., Chancellor Vanderbilt University, Nashville, Tenn. (25). 1877 B
Garman, Samuel, Museum Comparative Zoology, Cambridge, Mass. (20). 1874. F E
Gatschet, Dr. Albert S., Box 333, Washington, D. C. (30). 1882. H
Gibbs, Prof. J. Willard, New Haven, Conn. (33). 1885. B
Gilbert, G. K., Box 591, Washington, D. C. (18). 1874. E
Gill, Prof. Theo., Smithsonian Institution, Washington, D. C. (17). 1874.
Gillman, Henry, U. S. Consul, Jerusalem, Palestine, via England and Brindisi (24). 1875. H F
Gilman, Daniel C., President Johns Hopkins University, Baltimore, Md. (10). 1875. E H
Goessman, Prof. C. A., Mass. Agricultural College, Amherst, Mass. (18). 1875. C
Goff, E. S., Madison, Wis. (35). 1889.
Gold, Theodore S., West Cornwall, Conn. (4). 1887. B C
Goldschmidt, S. A., Ph.D., 55 Broadway, New York, N. Y. (24). 1880. C E B
Gooch, Frank A., Yale College, New Haven, Conn. (25). 1880. C
Goodale, Prof. G. L., Botanic Gardens, Cambridge, Mass. (18). 1875.
Goode, G. Brown, Curator Nat'l Museum, Washington, D. C. (22). 1874.
Goodfellow, Edward, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (24). 1879. A H
Gould, Dr. B. A., Cambridge, Mass. (2). 1875. A B
Grant, Mrs. Mary J., Brookfield, Conn. (23). 1874. A
Gratacap, L. P., Ph.B., 77th St. and 8th Ave., New York, N. Y. (27). 1884. C E F
Gray, Elisha, Sc.D., Highland Park, Ill. (32). 1883. B
Gray, Prof. Thomas, Terre Haute, Ind. (38). 1889.

Green, Arthur L., La Fayette, Ind. (38). 1888. **C**
Green, Traill, M.D., Easton, Pa. (1). 1874. **C F**
Grimes, J. Stanley (17). 1874. **E H**
Grinnell, George Bird, 40 Park Row, New York, N. Y. (25). 1885. **F E**
Gulley, Prof. Frank A., College Station, Texas (30). 1883.

Hagen, Dr. Hermann A., Museum Comparative Zoology, Cambridge, Mass. (17). 1875. **F**
Hague, Arnold, U. S. Geol. Survey, Washington, D. C. (26). 1879.
Haines, Reuben, Haines and Chew St., Germantown, Philadelphia, Pa. (27). 1889. **C B**
Hale, Albert C., Ph.D., No. 551 Putnam Ave., Brooklyn, N. Y. (29). 1886. **C B**
Hale, Horatio, Clinton, Ontario, Can. (30). 1882. **H**
Hall, Prof. Asaph, U. S. Naval Observatory, Washington, D. C. (25). 1877. **A**
Hall, Prof. C. W., 803 Univ. Ave. So., Minneapolis, Minn. (28). 1883. **E**
Hall, Prof. Edwin H., 5 Avon St., Cambridge, Mass. (29). 1881. **B**
Hall, Prof. James, Albany, N. Y. (1). 1875. **E F**
Hall, Prof. Lyman B., Haverford College, Pa. (31). 1884. **C**
Halsted, Byron D., New Jersey Agricultural Experiment Station, New Brunswick, N. J. (29). 1883. **F**
Hamlin, Dr. A. C., Bangor, Me. (10). 1874. **C E H**
HANAMAN, C. E., Troy, N. Y. (19). 1883. **F**
Hardy, Prof. A. S., Dartmouth College, Hanover, N. H. (28). 1883. **A**
HARKNESS, PROF. WILLIAM, U. S. N. Observatory, Washington, D. C. (26). 1878. **A B C D**
Harrington, H. H., College Station, Texas (35). 1889. **C**
Harris, Uriah R., Lieutenant U. S. N., U. S. S. Ranger, care of Navy Pay Office, San Francisco, Cal. (34). 1886. **A**
Harris, W. T., Lock Box 1, Concord, Mass. (27). 1887. **H I**
Hart, Edw., Ph.D., Easton, Pa. (33). 1885. **C**
Hasbrouck, Prof. I. E., 364 Carlton Ave., Brooklyn, N. Y. (23). 1874. **D A I**
HASTINGS, C. S., Sheffield Scientific School of Yale College, New Haven, Conn. (25). 1878. **B**
Haupt, Prof. Lewis M., University of Pennsylvania, Philadelphia, Pa. (32). 1885. **I D E**
Hay, Prof. O. P., Irvington, Ind. (37). 1889. **E F**
Haynes, Henry W., 239 Beacon St., Boston, Mass. (28). 1884. **H**
Heilprin, Prof. Angelo, Acad. Nat. Sciences, Philadelphia, Pa. (33). 1885. **E F**
Hendricks, J. E., Des Moines, Iowa (29). 1885. **A**
Henshaw, Henry W., Bureau of Ethnology, Washington, D. C. (24). 1877. **H**
Hering, Rudolph, Civil and Sanitary Engineer, 277 Pearl St., New York, N. Y. (33). 1885. **D E I**

Herrick, Clarence L., 12 Mason St., Mt. Auburn, Cincinnati, Ohio (31). 1884. F E

Hervey, Rev. A. B., Pres. St. Lawrence Univ., Canton, N.Y. (22). 1879. F

Hicks, Prof. Lewis E., State University, Lincoln, Neb. (31). 1885. E F

Hilgard, Prof. E. W., University of California, Berkeley, Cal. (11). 1874. C E B

Hilgard, Prof. J. E., Washington, D. C. (4). 1874. A

Hill, Chas. S., care Dep't of State, Washington, D. C. (33). 1887. A I

Hill, Robert Thomas, Univ. of Texas, Austin, Texas (36). 1889. E

Himes, Prof. Charles F., Carlisle, Pa. (29). 1882. B C

Hirschfelder, Chas. A., Vice Consul U. S. A., Toronto, Ontario, Can. (33). 1887. H

HITCHCOCK, PROF. CHARLES H., Hanover, N. H. (11). 1874. E

Hitchcock, Romyn, Washington, D. C. (29). 1881. C B

Hobbs, A. C., Bridgeport, Conn. (28). 1886. D

Hodges, N. D. C., Editorial office of Science, 47 Lafayette St., New York, N. Y. (29). 1882. B

Hoffmann, Dr. Fred., "Rundschau," P. O. Box 1680, New York, N. Y. (28). 1881. C F

Holden, Prof. E. S., Lick Observatory, San José, Cal. (23). 1875. A

Holman, Silas W., Massachusetts Institute of Technology, Boston, Mass. (31). 1883. B

Holmes, Prof. Jos. A., Chapel Hill, N. C. (33). 1887. E F

Holmes, Dr. Oliver Wendell, 296 Beacon St., Boston, Mass. (29). 1881. H

Holmes, Wm. H., Bureau of Ethnology, Smithsonian Institution, Washington, D. C. (30). 1883. H

Horsford, Prof. E. N., Cambridge, Mass. (1). 1876. C E

Hosea, Lewis M., Johnston Building, Cincinnati, Ohio (30). 1883.

Hotchkiss, Major Jed., Staunton, Va. (31). 1888. E H I

Hough, Prof. G. W., Director Dearborn Observatory, Evanston, Ill. (15). 1874. A

Hovey, Rev. Horace C., 14 Park St., Bridgeport, Conn. (29). 1883. E H

Howard, Leland O., Dep't of Agric., Washington, D. C. (37). 1889. F

Howe, Jas. Lewis, Louisville, Ky. (36). 1888. C

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Hulst, Rev. Geo. D., 15 Himrod St., Brooklyn, N. Y. (29). 1887. F

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Hunt, Dr. T. Sterry, Park Avenue Hotel, New York, N. Y. (1). 1874. C E

Hyatt, Prof. Alpheus, Natural History Society, Boston, Mass. (18). 1875. E

Hyde, Prof. E. W., Station D, Cincinnati, Ohio (25). 1881. A

Iddings, Joseph P., U. S. Geol. Survey, Washington, D. C. (31). 1884. E

Jacobus, David S., Stevens Institute, Hoboken, N. J. (36). 1889. D B A

James, Edmund J., Ph.D., Univ. of Pa., Philadelphia, Pa. (33). 1887. I

James, Jos. F., M.S., U. S. Geol. Survey, Washington, D. C. (30). 1882. F E

Jastrow, Dr. Jos., Johns Hopkins Univ., Baltimore, Md. (35). 1887. H F

Jayne, Horace F., 1826 Chestnut St., Philadelphia, Pa. (29). 1884. **F H**

Jeffries, B. Joy, M.D., 15 Chestnut St., Boston, Mass. (29). 1881. **F H**

Jenkins, Edw. H., New Haven, Conn. (33). 1885. **C**

Jenks, Elisha T., Middleborough, Mass. (22). 1874. **D**

Jenks, Prof. J. W. P., Middleborough, Mass. (2). 1874. **B**

Jewell, Theo. F., Commander U. S. Navy, Naval Torpedo Station and War College, Newport, R. I. (25). 1882. **B**

Jillson, Dr. B. C., 342 River Ave., E.E., Pittsburgh, Pa. (14). 1881. **E H F**

Johnson, Lawrence C., U. S. Geol. Survey, Gainesville, Fla. (33). 1887.

Johnson, Otis C., Ann Arbor, Mich. (34). 1886. **C**

Johnson, Prof. W. W., Naval Academy, Annapolis, Md. (29). 1881. **A**

Jordan, Prof. David S., Pres. Indiana Univ., Bloomington, Ind. (31). 1883. **F**

Joy, Prof. Charles A., care F. Hoffmann, Stockbridge, Mass. (8). 1879.

Julien, A. A., New York Acad. of Sciences, New York, N. Y. (24). 1875. **E C**

Kedzie, Prof. Robert C., Agricultural College, Mich. (29). 1881. **C**

Keiser, Edward H., Ph.D., Prof. of Chemistry, Bryn Mawr College, Bryn Mawr, Montgomery Co., Pa. (35). 1888. **C**

Kellicott, David S., Columbus, Ohio (31). 1883. **F**

Kemp, James F., Cornell Univ., Ithaca, N. Y. (36). 1888. **E**

Kendall, Prof. E. Otis, 3826 Locust St., Philadelphia, Pa. (29). 1882. **A**

Kent, William, Passaic, N. J. (26). 1881. **D I**

Kershner, Prof. Jefferson E., Lancaster City, Pa. (29). 1883. **A B**

Kimball, Arthur Lalanne, Johns Hopkins Univ., Baltimore, Md. (33). 1885. **B**

Kinnicutt, Dr. Leonard P., Polytechnic Inst., Worcester, Mass. (28). 1883. **C**

Kirkwood, Prof. Daniel, Arlington Ave., Riverside, Cal. (7). 1874. **A**

Klotz, Otto Julius, Preston, Ontario, Can. (33). 1889.

Kunz, G. F., 402 Garden St., Hoboken, N. J. (29). 1883. **E H C**

Ladd, E. F., Geneva, N. Y. (36). 1889. **C**

Laflamme, Prof. J. C. K., Laval Univ., Quebec, Can. (29). 1887. **E B**

LaFlesche, Francis, Indian Bureau, Interior Dep't, Washington, D. C. (33). 1885. **H**

Lambert, Rev. Thomas R., D.D., Hotel Oxford, Huntington Ave., Boston, Mass. (18). 1874.

Landreth, Prof. Olin H., Vanderbilt Univ., Nashville, Tenn. (28). 1883. **D**

Langdon, Dr. F. W., 65 West 7th St., Cincinnati, Ohio (30). 1882. **F H**

Langley, Prof. J. W., 5914 Walnut St., E. End, Pittsburgh, Pa. (23). 1875. **C B**

Langley, Prof. S. P., Secretary Smithsonian Institution, Washington, D. C. (18). 1874. **A B**

Lanza, Prof. Gaetano, Mass. Institute of Technology, Boston, Mass. (29). 1882. **D A B**

Larkin, Edgar L., Director Knox College Observatory, Galesburg, Ill. (28). 1888. A

Lattimore, Prof. S. A., University of Rochester, Rochester, N. Y. (15). 1874. C

Lawrence, George N., 45 E. 21st St., New York, N. Y. (7). 1877. F

Lazenby, Prof. Wm. R., Columbus, Ohio (30). 1882. B I

Leavenworth, Francis P., Haverford College P. O., Montgomery Co., Pa. (30). 1888. A

LeConte, Prof. Joseph, Univ. of Cal., Berkeley, Cal. (29). 1881. E F

Ledoux, Albert R., Ph.D., 39 W. 50th St., New York, N. Y. (26). 1881. C

Leeds, Prof. Albert R., Stevens Institute, Hoboken, N. J. (23). 1874. C F

Lehmann, G. W., Ph.D., 111 S. Gay St., Baltimore, Md. (30). 1885. C B

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Libbey, Prof. William, jr., Princeton, N. J. (29). 1887. E F

LILLY, GEN. WM., Mauch Chunk, Carbon Co., Pa. (28). 1882. (Patron) F E

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Lintner, J. A., N. Y. State Entomologist, Room 27, Capitol, Albany, N. Y. (22). 1874. F

Litton, Abram, 2220 Eugenia St., St. Louis, Mo. (28). 1879. C

Lloyd, Mrs. Rachel, Box 675, Lincoln, Neb. (31). 1889. C

Lockwood, Samuel, Ph.D., Freehold, Monmouth Co., N. J. (18). 1875. F B A

Lord, Prof. Nat. W., State Univ., Columbus, Ohio (29). 1881. C

Loudon, Prof. James, Toronto, Ontario, Can. (25). 1881. B A

Loughridge, Dr. R. H., South Carolina College, Columbia, S. C. (21). 1874. E C

Love, Edward G., School of Minès, Columbia College, New York, N. Y. (24). 1882. C

Lovering, Prof. Joseph, Harv. Univ., Cambridge, Mass. (2). 1875. B A

Lupton, Prof. N. T., Auburn, Ala. (17). 1874. C

Lyle, David Alexander, Captain Ordnance Dept. U. S. A., Ordnance Office, Washington, D. C. (28). 1880. D

Lyon, Dr. Henry, 34 Monument Sq., Charlestown, Mass. (18). 1874.

McAdams, Wm., Alton, Ill. (27). 1885. E H

McCauley, Capt. C. A. H., Ass't Q. M., U. S. A., 321 Michigan Ave., Chicago, Ill. (29). 1881.

McCreath, Andrew S., 223 Market St., Harrisburgh, Pa. (33). 1889. C E

McGee, W. J., U. S. Geol. Survey, Washington, D. C. (27). 1882. E

McGill, John T., Ph.D., Vanderbilt Univ., Nashville, Tenn. (36). 1888. C

McLeod, Prof. C. H., McGill Univ., Montreal, P. Q. Can. (35). 1887. A B D

McMurtrie, William, care New York Tartar Co., 68 William St., New York, N. Y. (22). 1874. C

McNeill, Malcolm, Lake Forest, Ill. (32). 1885. A
Mabery, Prof. C. F., Case School of Applied Science, Cleveland, Ohio (29). 1881. C
Macfarlane, Prof. A., Univ. of Texas, Austin, Texas (34). 1886. B A
Mackintosh, James B., Consolidated Gas Co., 21st St. and Ave. A, New York, N. Y. (27). 1883. C B
Macloskie, Prof. George, College of New Jersey, Princeton, N. J. (25). 1882. F
Magie, Prof. William F., College of New Jersey, Princeton, N. J. (35). 1887.
Mallery, Col. Garrick, U. S. Army, Bureau of Ethnology, Washington, D. C. (26). 1879. H
MANN, B. PICKMAN, 1918 Sunderland Place, Washington, D. C. (22). 1874. I F
Marcy, Oliver, LL.D., Evanston, Ill. (10). 1874. E
Markoe, Prof. Geo. F. H., 29 Montrose St., Roxbury, Mass. (29). 1881.
MARSH, PROF. O. C., Yale College, New Haven, Conn. (15). 1874. F H
Martin, Prof. Daniel S., 236 West 4th St., New York, N. Y. (23). 1879. E F
Martin, Prof. H. Newell, Johns Hopkins University, Baltimore, Md. (27). 1880. F H
Martin, Miss Lillie J., Girls High School, San Francisco, Cal. (32). 1886. F C
Martin, Prof. Wm. J., Davidson College, N. C. (31). 1884. C E
Mason, Prof. Otis T., National Mus., Washington, D. C. (25). 1877. H
Mason, Dr. William P., Prof. Rensselaer Polytechnic Inst., Troy, N. Y. (31). 1886. C
Matthews, Washington, 1262 New Hampshire Ave., cor. 21st St., N. W., Washington, D. C. (37). 1888. H
Maxwell, Rev. Geo. M., Wyoming, Hamilton Co., Ohio (30). 1886. H E
Mayer, Prof. A. M., South Orange, N. J. (19). 1874.
Meehan, Thomas, Germantown, Pa. (17). 1875. F
Mees, Prof. Carl Leo, Columbus, Ohio (24). 1876. B C
Mendenhall, Prof. T. C., U. S. C. and G. Survey, Washington, D. C. (20). 1874. B
Menocal, Anicito G., C.E., U. S. N., Navy Yard, Washington, D. C. (36). 1888. D
Merriam, C. Hart, M.D., Smith. Inst., Washington, D. C. (33). 1885. F
Merrill, Frederick J. H., Ph.B., 126 E. 60th St., New York, N. Y. (35). 1887. E
Merriman, C. C., 1910 Surf St., Lake View, Chicago, Ill. (29). 1880. F
Merriman, Prof. Mansfield, Lehigh University, Bethlehem, Pa. (32). 1885. A D
Metz, Charles L., M.D., Madisonville, Hamilton Co., Ohio (30). 1885. H
Michael, Mrs. Helen Abbott, 1509 Locust St., Philadelphia, Pa. (33). 1885. C F
Michelson, A. A., Master U. S. N., 7 Rockwell St., Cleveland, Ohio (26). 1879. B

Mills, T. Wesley, Montreal, P. Q., Can. (31). 1886. **F H**

Minot, Dr. Charles Sedgwick, 25 Mt. Vernon St., Boston, Mass. (28). 1880. **F**

Minot, Francis, M.D., 65 Marlborough St., Boston, Mass. (29). 1884.

Mixter, Prof. Wm. G., New Haven, Conn. (30). 1882. **C**

Moore, Prof. J. W., M.D., Lafayette College, Easton, Pa. (22). 1874. **B D A**

Moore, Robert, C.E., 61 Vanderventer Place, St. Louis, Mo. (33). 1887. **D B I**

Morgan, Frank H., Cornell Univ., Ithaca, N. Y. (35). 1889. **C**

Morley, Prof. Edward W., 749 Republic St., Cleveland, Ohio (18). 1876. **C B E**

Morong, Rev. Thomas, Ashland, Mass. (35). 1887. **F**

Morris, Rev. John G., Baltimore, Md. (12). 1874.

Morse, Prof. E. S., Salem, Mass. (18). 1874. **F H**

Morton, H., Stevens Institute Technology, Hoboken, N. J. (18). 1875. **B C**

Moser, Lieut. Jeff. F., U. S. N., Coast Survey Office, Washington, D. C. (28). 1889. **E**

Moses, Prof. Thos. F., Urbana Univ., Urbana, Ohio (25). 1883. **H F**

Munroe, Prof. C. E., Chemist to Bureau of Ordnance, U. S. Torpedo Station, Newport, R. I. (22). 1874. **C**

Murdoch, John, Smithsonian Institution, Washington, D. C. (29). 1886. **F H**

Murdock, J. B., Lieut. U. S. N., 24 Alaska St., Roxbury, Mass. (28). 1885. **B**

Murtfeldt, Miss Mary E., Kirkwood, Mo. (27). 1881. **F**

Myers, John A., Agric. Exper. Station, Morgantown, W. Va. (30). 1889. **C**

Nason, Frank L., 5 Union St., New Brunswick, N. J. (36). 1888. **E**

Nason, Prof. H. B., Rensselaer Polytechnic Institute, Troy, N. Y. (18). 1874. **C E**

Nelson, Prof. A. B., Centre College, Danville, Ky. (30). 1882. **A B D**

Newberry, Prof. J. S., Columbia College, New York, N. Y. (5). 1875. **E F H I**

Newberry, Prof. Spencer Baird, Ithaca, N. Y. (33). 1887. **C**

Newcomb, Prof. S., Navy Dep't, Washington, D. C. (13). 1874. **A B**

Newton, Hubert A., New Haven, Conn. (6). 1874. **A**

Nichols, E. L., Ph.D., Cornell Univ., Ithaca, N. Y. (28). 1881. **B C**

Nicholson, Prof. H. H., Box 675, Lincoln, Neb. (36). 1888.

Niles, Prof. W. H., Cambridge, Mass. (16). 1874.

Nipher, Prof. F. E., Washington Univ., St. Louis, Mo. (24). 1876. **B**

Norton, Lewis M., Ph.D., Mass. Institute of Technology, Boston, Mass. (29). 1884. **C**

NORTON, PROF. THOMAS H., Univ. of Cincinnati, Cincinnati, Ohio (35). 1887. **C**

Novy, Frederick George, Ann Arbor, Mich. (36). 1889.

Noyes, Prof. Wm. A., Rose Polytechnic Inst., Terre Haute, Ind. (32). 1885. C

Nuttall, Mrs. Zelia, care Peabody Museum, Cambridge, Mass. (35). 1887. H

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Ordway, Prof. John M., Tulane University, New Orleans, La. (9). 1875. C

Orton, Prof. Edward, President Ohio Agricultural and Mechanical College, Columbus, Ohio (19). 1875. E

Osborn, Henry F., S.D., Princeton, N. J. (29). 1883.

Osborn, Henry Leslie, 3 East 47th St., Hamline, Minn. (29). 1887.

Osborn, Herbert, Ames, Iowa (32). 1884. F

Osborne, J. W., 212 Delaware Ave. N. E., Washington, D. C. (22). 1874. D C B

Osmond, Prof. I. Thornton, State College, Centre Co., Pa. (33). 1889. B A C

Packard, Dr. A. S., 115 Angell St., Providence, R. I. (16). 1875. F E

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Paine, Nathaniel, Worcester, Mass. (18). 1874. H

Palfray, Hon. Charles W., Salem, Mass. (21). 1874.

Palmer, Chase, Ph.D., Wabash College, Crawfordsville, Ind. (38). 1889. C

Parke, John G., Gen. U. S. A., 16 Lafayette Square, Washington, D. C. (29). 1881. D

Parkhurst, Henry M., Law Stenographer, 25 Chambers St., New York, N. Y. (23). 1874. A

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Peabody, Cecil H., Ass't Prof. Steam Eng., Mass. Institute Technology, Boston, Mass. (32). 1887. D

Peabody, Selim H., Regent University of Illinois, Champaign, Ill. (17). 1885. D B F

Peckham, S. F., 159 Olney St., Providence, R. I. (18). 1875. C B E

Pedrick, Wm. R., Lawrence, Mass. (22). 1875.

Peet, Rev. Stephen D., Mendon, Ill. (24). 1881. H

Peirce, Benj. O., jr., Ass't Prof., Harvard College, Cambridge, Mass. (29). 1886. A B

Pengra, Charles P., M.D., 130 Dartmouth St., Boston, Mass. (34). 1887. F C

Perkins, Prof. George H., Burlington, Vt. (17). 1882. H F E

Peter, Dr. Robert, Kentucky Geol. Survey, Lexington, Ky. (29). 1881. C

Peters, Edw. T., P. O. Box 265, Washington, D. C. (33). 1889. I

Pettee, Prof. William H., Ann Arbor, Mich. (24). 1875. E

Phillips, A. W., New Haven, Conn. (24). 1879.
Phillips, Prof. Francis C., Western Univ., Allegheny, Pa. (36). 1889. C
Phillips, Henry, jr., 320 So. 11th St., Philadelphia, Pa. (32). 1887. H I
Phippen, Geo. D., Salem, Mass. (18). 1874. F
Pickering, Prof. E. C., Director of Observatory, Cambridge, Mass. (18). 1875. A B
Pickering, William H., Harvard Observatory, Cambridge, Mass. (29). 1883. B A
Pilling, James C., Box 591, Washington, D. C. (28). 1882. F H I
Pillsbury, Prof. John H., Smith College, Northampton, Mass. (28). 1885. F H
Platt, Franklin, Ass't Geologist, 2nd Geol. Survey of Pa., 615 Walnut St., Philadelphia, Pa. (27). 1882. E
Pohlman, Dr. Julius, Buffalo, N. Y. (32). 1884. E F
Porter, Thos. C., LL.D., Lafayette College, Easton, Pa. (33). 1887. F
Potter, William B., Washington Univ., St. Louis, Mo. (25). 1879.
Powell, Major J. W., U. S. Geologist, 910 M St. N. W., Washington, D. C. (23). 1875. E H
Power, Prof. Frederick B., Univ. of Wis., Madison, Wis. (31). 1887. C
Prentiss, Prof. A. N., Cornell Univ., Ithaca, N. Y. (35). 1887. F
Prentiss, D. Webster, M.D., 1101 14th St. N. W., Washington, D. C. (29). 1882. F
Prescott, Prof. Albert B., Ann Arbor, Mich. (23). 1875. C
Preston, E. D., Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (37). 1889. A E
Pritchett, Henry S., Director Observatory Washington University, St. Louis, Mo. (29). 1881. A
Procter, John R., Dir. Kentucky Geol. Surv., Frankfort, Ky. (26). 1881.
Pulsifer, Wm. H., 1837 Kennett Place, St. Louis, Mo. (26). 1879. A H
Pumpelly, Prof. Raphael, U. S. Geological Survey, Newport, R. I. (17). 1875. E I
Putnam, Prof. F. W., Curator Peabody Museum American Archæology and Ethnology, Cambridge, Mass. (Address as Permanent Secretary A. A. A. S., Salem, Mass.) (10). 1874. H
Pynchon, Rev. T. R., Trinity Coll., Hartford, Conn. (23). 1875.

Quincy, Edmund, 88 Clinton St., Boston, Mass. (11). 1874.

Rauch, Dr. John H., Springfield, Ill. (11). 1875.
Raymond, Rossiter W., 17 Burling Slip, New York, N. Y. (15). 1875. E I
Redfield, J. H., 216 W. Logan Square, Philadelphia, Pa. (1). 1874. F
Reed, E. Baynes, London, Ontario, Can. (27). 1882.
Rees, Prof. John K., Columbia College, New York, N. Y. (26). 1878. A E B
Remsen, Prof. Ira, Johns Hopkins Univ., Baltimore, Md. (22). 1875. C
Rice, John M., U. S. Naval Academy, Annapolis, Md. (25). 1881. A D

Rice, Prof. Wm. North, Wesleyan University, Middletown, Conn. (18). 1874. E F

Richards, Prof. Charles B., 318 York St., New Haven, Conn. (33). 1885. D

Richards, Edgar, Office of Internal Revenue, Treasury Dept., Washington, D. C. (31). 1886. C

Richards, Prof. Robert H., Mass. Inst. Tech., Boston, Mass. (22). 1875 D

Richards, Mrs. Robert H., Prof. Mass. Inst. of Tech., Boston, Mass. (23). 1878. C

Richardson, Clifford, Dep't of Agric., Washington, D. C. (30). 1884. C

Ricketts, Prof. Palmer C., 17 1st St., Troy, N. Y. (33). 1887. D A

Ricketts, Prof. Pierre de Peyster, School of Mines, Columbia College, New York, N. Y. (26). 1880. C D E

RILEY, PROF. C. V., U. S. Entomologist, 1700 18th St. N. W., Washington, D. C. (17). 1874. F H I

Ritchie, E. S., Newton Highlands, Mass. (10). 1877. B

Roberts, Prof. Isaac P., Ithaca, N. Y. (33). 1886. I

Robinson, Prof. Franklin C., Brunswick, Me. (29). 1889. C D

Robinson, Prof. S. W., Univ. of Ohio, Columbus, Ohio (30). 1883. D B A

Rockwell, Gen. Alfred P., Manchester, Mass. (10). 1882. E

Rockwell, Chas. H., Box 293, Tarrytown, N. Y. (28). 1883. A D

Rockwood, Prof. Charles G., jr., College of New Jersey, Princeton, N. J. (20). 1874. A E B D

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Rogers, Prof. W. A., Colby Univ., Waterville, Me. (15). 1875. A B D

Rominger, Dr. Carl, Ann Arbor, Mich. (21). 1879. E

Rood, Prof. O. N., Columbia College, New York, N. Y. (14). 1875. B

Ross, Waldo O., 31 Otis St., Boston, Mass. (29). 1882.

Rowland, Prof. Henry A., Baltimore, Md. (29). 1880.

Runkle, Prof. J. D., Mass. Institute of Technology, Boston, Mass. (2). 1875. A D

Russell, I. C., U. S. Geological Survey, Washington, D. C. (25). 1882.

Rutherford, Lewis M., 175 Second Ave., New York, N. Y. (13). 1875.

Sadtler, Prof. Sam'l P., Univ. of Pa., Philadelphia, Pa. (22). 1875. C

Safford, Dr. James M., Nashville, Tenn. (6). 1875. E C F

Salmon, Daniel E., Dep't of Agric., Washington, D. C. (31). 1885. F

Sampson, Commander W. T., U. S. N., Naval Acad., Annapolis, Md. (25). 1881. B A

Sanborn, Rev. John W., Lockport, N. Y. (33). 1886. H

Saunders, William, Director Agricultural Experiment Station, Ottawa, Ontario, Can. (17). 1874. F

Schaeberle, J. M., Astronomer in the Lick Observatory, San José, Cal. (34). 1886. A

Schanck, Prof. J. Stillwell, Princeton, New Jersey (4). 1882. C B H

Schott, Charles A., U. S. Coast and Geodetic Survey Office, Washington, D. C. (8). 1874. **A**

Schweinitz, Dr. E. A. v., Dept. of Agric., Washington, D.C. (36). 1889. **C**

Schweitzer, Prof. Paul, State University of Missouri, Columbia, Mo. (24). 1877. **C B**

Scott, Prof. Wm. B., Princeton, N. J. (38). 1887. **F E**

Scovell, M. A., Director Kentucky Agricultural Experiment Station, Lexington, Ky. (35). 1887.

Scribner, F. Lamson, U. S. Dep't of Agric., Washington, D. C. (34). 1887. **F**

SCUDDER, SAMUEL H., Cambridge, Mass. (13). 1874. **F**

Seaman, W. H., Chemist, 1424 11th St. N. W., Washington, D. C. (23). 1874. **C F**

See, Horace, 1 Broadway, New York, N. Y. (34). 1886. **D**

Seiler, Carl, M.D., 1346 Spruce St., Philadelphia, Pa. (29). 1882. **F B**

Seymour, William P., M.D., 105 Third St., Troy, N. Y. (19). 1888. **H**

Sharples, Stephen P., 13 Broad St., Boston, Mass. (29). 1884. **C**

Sharpless, Prof. Isaac, Haverford College, Pa. (33). 1888. **A**

Sheafer, P. W., Pottsville, Pa. (4). 1879. **E**

Shimer, Porter W., E.M., Easton, Pa. (38). 1889. **C**

Shutt, Frank T., M.A., F.E.C., F.C. S., Chemist to the Dominion Experimental Farms, Ottawa, Ontario, Can. (38). 1889.

Sias, Solomon, M.D., Schoharie, Schoharie Co., N. Y. (10). 1874.

Sigsbee, Chas. D., Comd'r U. S. N., U. S. Naval Acad., Annapolis, Md. (28). 1882. **D E**

Silliman, Prof. Justus M., Lafayette Coll., Easton, Pa. (19). 1874. **D E**

Simonds, Prof. Frederic W., Univ. of Texas, Austin, Texas. (25). 1888. **E F**

Skinner, Joseph J., Massachusetts Inst. Technology, Boston, Mass. (23). 1880. **B**

Smiley, Charles W., U. S. Fish Commission, Washington, D. C. (28). 1883. **I**

Smith, Prof. Chas. J., 35 Adelbert St., Cleveland, Ohio (32). 1885. **A B**

Smith, Edwin, Ass't U. S. Coast and Geodetic Survey, Washington, D. C. (30). 1882. **A B**

Smith, Prof. Erastus G., Beloit College, Beloit, Wis. (34). 1887. **C**

Smith, Prof. Eugene A., University, Ala. (20). 1877. **E C**

Smith, Prof. Francis H., University of Virginia, Charlottesville, Va. (26). 1880. **B A**

Smith, John B., Professor of Entomology, Rutgers College, New Brunswick, N. J. (32). 1884. **F**

SMITH, QUINTIUS C., M.D., No. 617 Colo. St., Austin, Texas (26). 1881. **F**

Smith, Prof. S. I., Yale College, New Haven, Conn. (18). 1875. **F**

Smith, Dr. Theobald, Bureau of Animal Industry, U. S. Dep't of Agric., Washington, D. C. (35). 1887. **F**

Smock, Prof. John Conover, New York State Museum, Albany, N. Y. (23). 1879. **E**

Snow, Prof. F. H., Lawrence, Kan. (29). 1881. **F E**
Snow, Benj. W., Cornell Univ., Ithaca, N. Y. (35). 1889. **B**
Snyder, Henry, B.Sc., Miami Univ., Oxford, Ohio (30). 1888. **B C**
Snyder, Prof. Monroe B., High School Observatory, Philadelphia, Pa. (24). 1882. **A B**
Soule, R. H., Gen. Agent, The Union Switch & Signal Co., Pittsburgh, Pa. (33). 1886. **D**
Spalding, Volney M., Ann Arbor, Mich. (34). 1886. **F**
Spencer, Guilford L., Dept. Agric., Washington, D. C. (36). 1889. **C D**
Spencer, Prof. J. William, Prof. of Geology, University of Georgia, Athens, Ga. (28). 1882. **E**
Springer, Dr. Alfred, Box 621, Cincinnati, Ohio (24). 1880. **C**
Staley, Cady, LL.D., Pres. Case School of Applied Sciences, Cleveland, Ohio (37). 1888. **D**
Stearns, R. E. C., care Smithsonian Institution, Washington, D. C. (18). 1874. **F**
Steiner, Dr. Lewis H., Enoch Pratt Free Library, Baltimore, Md. (7). 1874. **I**
STEPHENS, W. HUDSON, Lowville, N. Y. (18). 1874. **E H**
Sternberg, George M., Major and Surgeon U. S. A., Johns Hopkins Univ., Baltimore, Md. (24). 1880. **F**
Stevens, W. LeConte, 170 Joralemon St., Brooklyn, N. Y. (29). 1882. **B A C**
Stevenson, Prof. John J., Univ. of New York, New York, N. Y. (36). 1888.
Stockwell, John N., 1008 Case Avenue, Cleveland, Ohio (18). 1875. **A**
Stoddard, Prof. John T., Smith Coll., Northampton, Mass. (35). 1889. **B C**
Stone, George H., Colorado Springs, Col. (29). 1882. **E F**
Stone, Mrs. Leander, Pres. Y. W. C. A., 3352 Indiana Avenue, Chicago, Ill. (22). 1874. **F E**
Stone, Ormond, Director Leander McCormick Observatory, University of Virginia, Va. (24). 1876. **A**
Story, Wm. E., Johns Hopkins Univ., Baltimore, Md. (29). 1881. **A**
Stowell, Prof. T. B., Potsdam, N. Y. (28). 1885. **F**
Stringham, Prof. Irving, Univ. of Cal., Berkeley, Cal. (33). 1885. **A**
Stuart, Prof. A. P. S., Lincoln, Nebraska (21). 1874. **C**
Sturtevant, E. Lewis, M.D., Geneva, N. Y. (29). 1882. **F**
Swift, Lewis, Ph.D., Rochester, N. Y. (29). 1882. **A**

Tainter, Charles Sumner, "The Gerlach," 55 W. 27th St., New York, N. Y. (29). 1881. **B D A**
Taylor, H. C., Commander U. S. N., Poughkeepsie, N. Y. (30). 1889.
Taylor, Thos., M.D., Dep't of Agric., Washington, D. C. (29). 1885. **F C**
Taylor, William B., Smithsonian Institution, Washington, D. C. (29). 1881. **B A**
Terry, Prof. N. M., U. S. Naval Academy, Annapolis, Md. (23). 1874. **B**
Thomas, Benj. F., Ph.D., State Univ., Columbus, Ohio (29). 1882. **B A**
Thomson, Elihu, Thomson-Houston Electric Co., Lynn, Mass. (37). 1888. **B**

Thomson, Wm., M.D., 1426 Walnut St., Philadelphia, Pa. (33). 1885. B

Thurston, Prof. R. H., Sibley College, Cornell University, Ithaca, N. Y. (23). 1875. D

Tittmann, Otto H., U. S. Coast and Geodetic Survey Office, Washington, D. C. (24). 1888. A

Todd, Prof. David P., Director Lawrence Observatory, Amherst College, Amherst, Mass. (27). 1881. A B D

Todd, Prof. James E., Tabor, Fremont Co., Iowa (22). 1886. E F

Towne, Henry R., Pres. Yale and Towne Manufacturing Co., Stamford, Conn. (33). 1888. D B

Townshend, Prof. N. S., Ohio State Univ., Columbus, Ohio (17). 1881. F H

Tracy, Sam'l M., Agricultural College, Miss. (27). 1881. F

Traphagen, Frank W., Ph.D., Prof. of Chemistry, The College of Montana, Deer Lodge City, Montana (35). 1889. C F E

Trembley, J. B., M.D., 952 8th St., Oakland, Alameda Co., Cal. (17). 1880. B F

Trimble, Prof. Henry, 145 No. 10 St., Philadelphia, Pa. (34). 1889. C

Trowbridge, Prof. W. P., School of Mines, Columbia College, New York, N. Y. (10). 1874. D

True, Fred W., U. S. National Museum, Washington, D. C. (28). 1882. F

Trumbull, Dr. J. Hammond, Hartford, Conn. (29). 1882. H

Tucker, Willis G., M.D., Albany Med. Coll., Albany, N. Y. (29). 1888. C

Tuttle, Prof. Albert H., Univ. of Virginia, Va. (17). 1874. F

Uhler, Philip R., 218 W. Hoffman St., Baltimore, Md. (19). 1874. F E

Underwood, Prof. Lucien M., cor. Comstock Ave. and Marshall St., Syracuse, N. Y. (33). 1885. F

Upham, Warren, 21 Newbury St., Somerville, Mass. (25). 1880. E

Upton, Winslow, Brown Univ., Providence, R. I. (29). 1883. A

Van der Weyde, P. H., M.D., 236 Duffield St., Brooklyn, N. Y. (17). 1874. B

Van Dyck, Prof. Francis Cuyler, New Brunswick, N. J. (28). 1882. B C F

Van Vleck, Prof. John M., Middletown, Conn. (23). 1875. A

Vasey, George, M.D., Dep't of Agric., Washington, D. C. (32). 1889. F

Vaughn, Dr. Victor C., Ann Arbor, Mich. (34). 1887. C

Very, Samuel W., Lieut. Comdr. U. S. N., U. S. S. Santee, Naval Acad., Annapolis, Md. (28). 1886. A B

Vining, Edward P., N. Y. & N. E. R. R. Co., 246 Federal St., Boston, Mass. (32). 1887. H

Vogdes, A. W., 1st Lt. 5th Art'y U. S. A., The Military Service Inst., Governor's Island, N. Y. (32). 1885. E F

Wachsmuth, Charles, 111 Marietta St., Burlington, Iowa (30). 1884. E F

Wadsworth, Prof. M. Edward, Ph.D., Director of the Michigan Mining School, State Geologist of Michigan, Houghton, Mich. (23). 1874. E

Walcott, Charles D., U. S. Geological Survey, Washington, D. C. (25). 1882. E F

Waldo, Prof. Clarence, A., Rose Polytechnic Inst., Terre Haute, Ind. (37) 1889. **A**

Waldo, Leonard, S.D., Lockport, N. Y. (28). 1880. **A**

Wallace, Wm., Ansonia, Conn. (28). 1882.

WALLER, E., School of Mines, Columbia College, New York, N. Y. (23). 1874.

Walmsley, W. H., 1016 Chestnut St., Philadelphia, Pa. (28). 1883. **F**

Ward, Prof. Henry A., Rochester, N. Y. (18). 1875. **F E H**

Ward, Lester F., U. S. Geological Survey, Washington, D. C. (26). 1879. **E F**

Ward, Dr. R. H., 53 Fourth St., Troy, N. Y. (17). 1874. **F B**

Ward, Wm. E., Port Chester, N. Y. (36). 1889. **D**

Warder, Prof. Robert B., Howard Univ., Washington, D. C. (19). 1881. **C B**

WARNER, JAMES D., 199 Baltic St., Brooklyn, N. Y. (18). 1874. **A B**

Warner, Worcester R., 887 Case Ave., Cleveland, Ohio (33). 1888. **A B D**

Warren, Cyrus M., Brookline, Mass. (29). 1882. **C**

Warren, Dr. Joseph W., Harvard Med. School, Boston, Mass. (31). 1886. **F**

Warren, Prof. S. Edward, Newton, Mass. (17). 1875. **A—I**

Watson, Sereno, Botanic Gardens, Cambridge, Mass. (22). 1875. **F**

WATSON, PROF. WM., 107 Marlborough St., Boston, Mass. (12). 1884. **A**

Webb, Prof. J. Burkitt, Stevens Inst., Hoboken, N. J. (31). 1883. **D B A**

Weber, Prof. Henry A., Ohio State Univ., Columbus, Ohio. (35). 1888. **F**

Webster, Prof. N. B., Grove House, Vineland, N. J. (7). 1874. **B C E**

Wells, Daniel H., Hartford, Conn. (18). 1875. **A I**

Westcott, O. S., Maywood, Cook Co., Ill. (21). 1874. **H F A**

Weston, Edward, 645 High St., Newark, N. J. (33). 1887. **B C D**

Wheatland, Dr. Henry, President Essex Inst., Salem, Mass. (1). 1874.

Wheeler, Prof. C. Gilbert, 81 Clark St., Chicago, Ill. (18). 1883. **C E**

Wheeler, Orlando B., Office Mo. River Com., 1515 Lucas Place, St. Louis, Mo. (24). 1882. **A D**

Wheildon, W. W., Box 229, Concord, Mass. (18). 1874. **B E**

White, Prof. C. A., Le Droit Park, Washington, D. C. (17). 1875. **E F**

White, Prof. H. C., Univ. of Georgia, Athens, Ga. (29). 1885. **C**

White, Prof. I. C., Univ. of W. Va., Morgantown, W. Va. (25). 1882. **E**

Whiteaves, J. F., Geol. Survey, Ottawa, Ontario, Can. (31). 1887. **E F**

Whitfield, R. P., American Museum Natural History, 77th St. & 8th Avenue, New York, N. Y. (18). 1874. **E F H**

Whiting, Miss Sarah F., Wellesley College, Wellesley, Mass. (31). 1883. **B A**

Whitman, Prof. Frank P., Adelbert College, Cleveland, Ohio (33). 1885.

Wilbur, A. B., Middletown, N. Y. (23). 1874.

Wilder, Prof. Burt G., Cornell University, Ithaca, N. Y. (22). 1875. **F**

Wiley, Prof. Harvey W., Dep't of Agric., Washington, D.C. (21). 1874. **C**

Williams, Benezette, 171 La Salle St., Chicago, Ill. (33). 1887. **D**

Williams, Charles H., M.D., C. B. and Q. Gen. Office, Chicago, Ill. (22). 1874.

Williams, Geo. Huntington, Johns Hopkins Univ., Baltimore, Md. (33). 1886. **E**

Williams, Henry Shaler, Cornell Univ., Ithaca, N. Y. (18). 1882. **E F**

Williams, Prof. Henry W., 15 Arlington St., Boston, Mass. (11). 1874. **H F**

Williams, Prof. S. G., Cornell Univ., Ithaca, N. Y. (33). 1885. **E**

Willson, Prof. Frederick N., Princeton, N. J. (33). 1887. **A D**

Wilson, Sir Daniel, President University College, 117 Bloor St., Toronto, Ontario, Canada (25). 1876. **H E**

Wilson, Joseph M., Room 1036, Drexel Building, Philadelphia, Pa. (33). 1886. **D**

Wilson, Thomas, U. S. Nat'l Museum, Washington, D. C. (36). 1888. **H.**

Wilson, William Powell, 640 No. 32nd St., Philadelphia, Pa. (38). 1889. **F**

Winchell, Prof. Alex., Ann Arbor, Mich. (8). 1875. **E**

Winchell, Prof. N. H., Univ. of Minnesota, Minneapolis, Minn. (19). 1874. **E H**

Winlock, Wm. C., Smithsonian Institution, Washington, D. C. (33). 1885. **A B**

Winslow, Arthur, State Geologist, Jefferson City, Mo. (37). 1889. **E**

Wood, Prof. De Volson, Hoboken, N. J. (29). 1881.

Woodbury, C. J. H., 31 Milk St., Boston, Mass. (29). 1884. **D**

Woodward, Prof. Calvin M., 1761 Missouri Ave., St. Louis, Mo. (32). 1884. **D A I**

Woodward, R. S., care of U. S. Geol. Survey, Washington, D. C. (33). 1885. **A B D**

Wormley, T. G., Univ. of Pennsylvania, Philadelphia, Pa. (20). 1878.

Worthen, W. E., 63 Bleeker St., New York, N. Y. (36). 1888. **D**

Wrampelmeier, Theo. J., San Diego, Cal. (34). 1887. **C**

Wright, Prof. Albert A., Oberlin College, Oberlin, Ohio (24). 1880. **E F**

Wright, Prof. Arthur W., Yale Coll., New Haven, Conn. (14). 1874. **A B**

Wright, Rev. Geo. F., Oberlin College, Oberlin, Ohio (29). 1882. **E**

Wright, Prof. Thos. W., Union College, Schenectady, N. Y. (36). 1889.

Würtele, Rev. Louis C., Acton Vale, P. Q., Can. (11). 1875. **E**

Youmans, Wm. Jay, M.D., Popular Science Monthly, 1-5 Bond St., New York, N. Y. (28). 1889. **F C**

Young, A. V. E., Northwestern Univ., Evanston, Ill. (33). 1886. **C B**

Young, C. A., Prof. of Astronomy, College of New Jersey, Princeton, N. J. (18). 1874. **A B D**

[724 FELLOWS.]

SUMMARY.—PATRONS, 3; MEMBERS, 1229; HONORARY FELLOW, 1; FELLOWS, 723.

JUNE 18, 1890, TOTAL NUMBER OF MEMBERS OF THE ASSOCIATION, 1956.

DECEASED MEMBERS.

[Unless by special vote of the Council, the names of those only who are members of the Association at the *time of their decease* will be included in this list. Information of the date and place of birth and death, to fill blanks in this list, is requested by the Permanent Secretary.]

Abbe, George W., New York, N. Y. (23). Died Sept. 25, 1879.

Abert, John James, Washington, D. C. (1). Born in Shepherdstown, Va., Sept. 17, 1788. Died in Washington, D. C., Sept. 27, 1863.

Adams, Charles Baker, Amherst, Mass. (1). Born in Dorchester, Mass., Jan. 11, 1814. Died in St. Thomas, W. I., Jan. 19, 1853.

Adams, Edwin F., Charlestown, Mass. (18).

Adams, Samuel, Jacksonville, Ill. (18). Born Dec. 19, 1806. Died April 29, 1877.

Agassiz, Louis, Cambridge, Mass. (1). Born in Parish of Motier, Switzerland, May 28, 1807. Died in Cambridge, Mass., Dec. 14, 1873.

Ainsworth, J. G., Barry, Mass. (14).

Alexander, Stephen, Princeton, N. J. (1). Born Sept. 1, 1806. Died June 25, 1883.

Allen, Thomas, St. Louis, Mo. (27). Died April 8, 1882.

Allen, Zachariah, Providence, R. I. (1). Born in Providence, R. I., Sept. 15, 1795. Died March 17, 1882.

Allston, Robert Francis Withers, Georgetown, S. C. (3). Born in All Saints Parish, S. C., April 21, 1801. Died near Georgetown, S. C., April 7, 1864.

Alvord, Benjamin, Washington, D. C. (17). Born in Rutland, Vt., Aug. 18, 1813. Died Oct. 16, 1884.

Ames, M. P., Springfield, Mass. (1). Born in 1803. Died April 23, 1847.

Andrews, Ebenezer Baldwin, Lancaster, Ohio (7). Born in Danbury, Conn., April 29, 1821. Died in Lancaster, Ohio, Aug. 14, 1880.

Anthony, Charles H., Albany, N. Y. (6). Died in 1874.

Appleton, Nathan, Boston, Mass. (1). Born in New Ipswich, N. H., Oct. 6, 1779. Died July 14, 1861.

Armstrong, John W., Fredonia, N. Y. (24).

Ashburner, Wm., San Francisco, Cal. (29). Born in Stockbridge, Mass., March, 1831. Died in San Francisco, Cal., April 20, 1887.

Atwater, Mrs. S. T., Chicago, Ill. (17). Born Aug. 8, 1812. Died April 11, 1878.

Aufrecht, Louis, Cincinnati, Ohio (30).

Bache, Alexander Dallas, Washington, D. C. (1). Born in Philadelphia, Pa., July 19, 1806. Died at Newport, R. I., Feb. 17, 1867.

Bache, Franklin, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Oct. 25, 1792. Died March 19, 1864.

Bailey, Jacob Whitman, West Point, N. Y. (1). Born in Auburn, Mass., April 29, 1811. Died in West Point, N. Y., Feb. 26, 1857.

Baird, Spencer Fullerton, Washington, D. C. (1). Born in Reading, Pa., Feb. 3, 1823. Died in Wood's Holl, Mass., Aug. 19, 1887.

Bardwell, F. W., Lawrence, Kan. (18). Died in 1878.

Barnard, F. A. P., New York, N. Y. (7). Born in Sheffield, Mass., May 5, 1809. Died in New York, April 27, 1889.

Barnard, John Gross, New York, N. Y. (14). Born in Sheffield, Mass., May 19, 1815. Died in Detroit, Mich., May 14, 1882.

Barrett, Dwight H., Baltimore, Md. (36). Died in March, 1889.

Barrett, Moses, Milwaukee, Wis. (21). Died in 1878.

Barry, Redmond, Melbourne, Australia (25).

Bassett, Daniel A., Los Angeles, Cal. (29). Born Dec. 8, 1819. Died May 26, 1887.

Bassnett, Thomas, Jacksonville, Fla. (8). Born 1807. Died in Jacksonville, Fla., Feb. 16, 1886.

Bayne, Herbert Andrew, Kingston, Ont., Can. (29). Born in Londonderry, Nova Scotia, Aug. 16, 1846. Died in Pictou, Can., Sept. 16, 1886.

Beach, J. Watson, Hartford, Conn. (23). Born Dec. 28, 1823. Died Mar. 16, 1887.

Beck, C. F., Philadelphia, Pa. (1).

Beck, Lewis Caleb, New Brunswick, N. J. (1). Born in Schenectady, N. Y., Oct. 4, 1798. Died April 20, 1853.

Beck, Theodoric Romeyn, Albany, N. Y. (1). Born in Schenectady, N. Y., Aug. 11, 1791. Died in Utica, N. Y., Nov. 19, 1855.

Beckwith, Henry C., Coleman's Station, N. Y. (29). Died July 12, 1885.

Belfrage, G. W., Clifton, Texas (29). Died Dec. 7, 1882.

Belknap, William B., Louisville, Ky. (29).

Bell, Samuel N., Manchester, N. H. (7). Born in Chester, N. H., March 25, 1829. Died in Manchester, N. H., Feb. 8, 1889.

Belt, Thomas, London, Eng. (27). Died Sept. 8, 1878.

Benedict, George Wyllys, Burlington, Vt. (16). Born Jan. 11, 1796. Died Sept. 23, 1871.

Bicknell, Edwin, Boston, Mass. (18). Born in 1830. Died March 19, 1877.

Binney, Amos, Boston, Mass. (1). Born in Boston, Mass., Oct. 18, 1803. Died in Rome, Feb. 18, 1847.

Binney, John, Boston, Mass. (3).

Blackie, Geo. S., Nashville, Tenn. (26).

Blair, Henry W., Washington, D. C. (26). Died Dec. 15, 1884.

Blake, Eli Whitney, New Haven, Conn. (1). Born Jan. 27, 1795. Died Aug. 18, 1886.

Blake, Homer Crane, New York, N. Y. (28). Born in Cleveland, Ohio, Feb. 1, 1822. Died in New York, N. Y., Jan. 20, 1880.

Blanding, William, ——, R. I. (1).

Blatchford, Thomas W., Troy, N. Y. (6).

Blatchley, Miss S. L., New Haven, Conn. (19). Died March 13, 1873.

Boadle, John, Haddonfield, N. J. (20). Born in 1805. Died in July, 1878.

Bomford, George, Washington, D. C. (1). Born in New York, 1780. Died in Boston, Mass., March 25, 1848.

Bowles, Miss Margaretta, Columbia, Tenn. (26). Died July, 1887.

Bowron, James, South Pittsburg, Tenn. (26). Died in Dec., 1877.

Bradley, Leverette, Jersey City, N. J. (15). Died in 1875.

Braithwaite, Jos., Chambly, C. W. (11).

Briggs, Albert D., Springfield, Mass. (13). Died Feb. 20, 1881.

Briggs, Robert, Philadelphia, Pa. (29). Born May 18, 1822. Died July 24, 1882.

Brigham, Charles Henry, Ann Arbor, Mich. (17). Born in Boston, Mass., July 27, 1820. Died Feb. 19, 1879.

Brown, Andrew, Natchez, Miss. (1).

Brown, Horace, Salem, Mass. (27). Died in July, 1883.

Bull, John, Washington, D. C. (31). Born Aug. 1, 1819. Died June 9, 1884.

Burbank, L. S., Woburn, Mass. (18).

Burke, Joseph Chester, Middletown, Conn. (29). Died in 1885.

Burnap, George Washington, Baltimore, Md. (12). Born in Merrimack, N. H., Nov. 30, 1802. Died in Philadelphia, Pa., Sept. 8, 1859.

Burnett, Waldo Irving, Boston, Mass. (1). Born in Southborough, Mass., July 12, 1828. Died in Boston, Mass., July 1, 1854.

Butler, Thomas Belden, Norwalk, Conn. (10). Born Aug. 22, 1806. Died June 8, 1873.

Cairns, Frederick A., New York, N. Y. (27). Died in 1879.

Campbell, Mrs. Mary H., Crawfordsville, Ind. (22). Died Feb. 27, 1882.

Carpenter, Thornton, Camden, S. C. (7).

Carpenter, William M., New Orleans, La. (1).

Case, Leonard, Cleveland, Ohio (15). Born June 27, 1820. Died Jan. 5, 1880.

Case, William, Cleveland, Ohio (6).

Caswell, Alexis, Providence, R. I. (2). Born Jan. 29, 1799. Died in Providence, R. I., Jan. 8, 1877.

Chadbourne, Paul Ansel, Amherst, Mass. (10). Born in North Berwick, Me., Oct. 21, 1823. Died Feb. 23, 1883.

Chapman, Nathaniel, Philadelphia, Pa. (1). Born in Alexandria Co., Va., May 28, 1780. Died July 1, 1853.

Chase, Pliny Earle, Haverford College, Pa. (18). Born in Worcester, Mass., Aug. 18, 1820.

Chase, Stephen, Hanover, N. H. (2). Born in 1818. Died Aug. 5, 1851.

Chauvenet, William, St. Louis, Mo. (1). Born May 24, 1819. Died Dec. 13, 1870.

Cheesman, Louis Montgomery, Hartford, Conn. (32). Born in 1858. Died in Jan., 1885.

Cheney, Miss Margaret S., Jamaica Plain, Mass. (29). Died in 1882.

Chevreul, Michel Eugène, Paris, France (35). Born in Angiers, France, Aug. 31, 1786. Died April 9, 1889.

Clapp, Asahel, New Albany, Ind. (1). Born Oct. 5, 1792. Died Dec. 15, 1862.

Clark, Henry James, Cambridge, Mass. (18). Born in Easton, Mass., June 22, 1826. Died in Amherst, Mass., July 1, 1873.

Clark, Joseph, Cincinnati, Ohio (5).

Clark, Patrick, Rahway, N. J. (33). Died March 5, 1887.

Clarke, A. B., Holyoke, Mass. (13).

Cleaveland, C. H., Cincinnati, Ohio (9).

Cleveland, A. B., Cambridge, Mass. (2).

Coffin, James Henry, Easton, Pa. (1). Born in Northampton, Mass., Sept. 6, 1806. Died Feb. 6, 1873.

Coffin, John H. C., Washington, D. C. (1). Born in Wiscasset, Maine, Sept. 14, 1815. Died in Washington, D. C., Jan. 8, 1890.

Coffinberry, Wright Lewis, Grand Rapids, Mich. (20). Born in Lancaster, Ohio, April 5, 1807. Died in Grand Rapids, Mich., March 26, 1889.

Colburn, E. M., Peoria, Ill. (33). Born in Rome, N. Y., Sept. 13, 1813. Died in Peoria, Ill., May 29, 1890.

Cole, Frederick, Montreal, Can. (31). Died in 1887.

Cole, Thomas, Salem, Mass. (1). Born Dec. 24, 1779. Died June 24, 1852.

Coleman, Henry, Boston, Mass. (1).

Collins, Frederick, Washington, D. C. (28). Born Dec. 5, 1842. Died Oct. 27, 1881.

Conrad, Timothy Abbott, Philadelphia, Pa. (1). Born in New Jersey, June 21, 1803. Died Aug. 9, 1877.

Cook, George H., New Brunswick, N. J. (4). Born in Hanover, Morris County, in 1818. Died in New Brunswick, N. J., Sept. 22, 1889.

Cooke, Caleb, Salem, Mass. (18). Born Feb. 15, 1838. Died June 5, 1880.

Cooper, William, Hoboken, N. J. (9). Died in 1864.

Copes, Joseph S., New Orleans, La. (11). Born Dec. 9, 1811. Died March 1, 1885.

Corning, Erastus, Albany, N. Y. (6). Born in Norwich, Conn., Dec. 14, 1794. Died April 9, 1872.

Costin, M. P., Fordham, N. Y. (30). Died June 8, 1884.

Couper, James Hamilton, Darien, Ga. (1). Born March 5, 1794. Died July 3, 1866.

Cramp, John Mockett, Wolfville, N. S. (11). Born in Kent, England, July 25, 1796. Died Dec. 6, 1881.

Crehore, John D., Cleveland, Ohio (24).

Crocker, Charles F., Lawrence, Mass. (22). Died in July, 1881.

Crocker, Miss Lucretia, Boston, Mass. (29). Died in 1886.

Crosby, Alpheus, Salem, Mass. (10). Born in Sandwich, N. H., Oct. 13, 1810. Died April 17, 1874.

Crosby, Thomas Russell, Hanover, N. H. (18). Born Oct. 22, 1816. Died March 1, 1872.

Croswell, Edwin, Albany, N. Y. (6). Born in Catskill, N. Y., May 29, 1797. Died June 13, 1871.

Crow, Wayman, St. Louis, Mo. (27). Born March 7, 1808. Died May 10, 1885.

Cummings, Joseph R., Evanston, Ill. (13). Died in Evanston, Ill., May 4, 1890, aged 74 years.

Curry, W. F., Geneva, N. Y. (11).

Curtis, Josiah, Washington, D. C. (18). Died Aug. 1, 1883.

Dalrymple, Edwin Augustine, Baltimore, Md. (11). Born in Baltimore, Md., June 4, 1817. Died Oct. 30, 1881.

Danforth, Edward, Elmira, N. Y. (11). Died in Elmira, N. Y., June 13, 1888.

Davenport, H. W., Washington, D. C. (30).

Dayton, Edwin A., Madrid, N. Y. (7). Born in 1827. Died June 24, 1878.

Dean, Amos, Albany, N. Y. (6). Born in Barnard, Vt., Jan. 16, 1803. Died Jan. 26, 1868.

Dearborn, George H. A. S., Roxbury, Mass. (1).

Dekay, James Ellsworth, New York, N. Y. (1). Born in New York, 1792. Died Nov. 21, 1851.

Delano, Joseph C., New Bedford, Mass. (5). Born Jan. 9, 1796. Died Oct. 16, 1886.

De Laski, John, Carver's Harbor, Me. (18).

Devereux, John Henry, Cleveland, Ohio (18). Born in Boston, Mass., April 5, 1832. Died in Cleveland, Ohio, March 17, 1886.

Dewey, Chester, Rochester, N. Y. (1). Born in Sheffield, Mass., Oct. 25, 1781. Died Dec. 15, 1867.

Dexter, G. M., Boston, Mass. (11).

Dillingham, W. A. P., Augusta, Me. (17).

Dimmick, L. N., Santa Barbara, Cal. (29). Died May 31, 1884.

Dinwiddie, Hardaway H., College Station, Texas (32). Died Dec. 11, 1887.

Dinwiddie, Robert, New York, N. Y. (1). Born in Dumfries, Scotland, July 23, 1811. Died in New York, N. Y., July 12, 1888.

Dixwell, Geo. B., Boston, Mass. (29). Died April, 1885.

Doggett, George Newell, Chicago, Ill. (33). Born in Chicago, Ill., Dec. 19, 1858. Died in Fredericksburg, Va., Jan. 15, 1887.

Doggett, Mrs. Kate Newell, Chicago, Ill. (17). Born in Castleton, Vt., Nov. 5, 1828. Died in Havana, Cuba, March 13, 1884.

Doggett, Wm. E., Chicago, Ill. (17). Born Nov. 20, 1820. Died in 1876.

Doolittle, L., Lenoxville, C. E. (11). Died in 1862.

Dorr, Ebenezer Pearson, Buffalo, N. Y. (25). Born in Hartford, Vt. Died in Buffalo, N. Y., April 29, 1882.

Draper, Henry, New York, N. Y. (28). Born in New York, N. Y., March 7, 1837. Died Nov. 20, 1882.

Ducatel, Julius Timoleon, Baltimore, Md. (1). Born in Baltimore, Md., June 6, 1798. Died April 25, 1849.

Duffield, George, Detroit, Mich. (10). Born in Strasburg, Pa., July 4, 1794. Died in Detroit, Mich., June 26, 1869.

Dumont, A. H., Newport, R. I. (14).

Dun, Walter Angus, Cincinnati, Ohio (31). Born March 1, 1857. Died Nov. 7, 1887.

Duncan, Lucius C., New Orleans, La. (10). Born in 1801. Died Aug. 9, 1855.
Dunn, R. P., Providence, R. I. (14).

Eads, James Buchanan, New York, N. Y. (27). Born May 23, 1820. Died March 8, 1887.
Easton, Norman, Fall River, Mass. (14). Died Dec. 21, 1872.
Eaton, James H., Beloit, Wis. (17). Died Jan. 5, 1877.
Elliott, Ezekiel Brown, Washington, D. C. (10). Born July 16, 1823. Died May 24, 1888.
Elsberg, Louis, New York, N. Y. (23). Born in Iserlohn, Prussia, April 2, 1836. Died in New York, N. Y., Feb. 19, 1885.
Elwyn, Alfred Langdon, Philadelphia, Pa. (1). Born in Portsmouth, N. H., July 9, 1804. Died in Philadelphia, Pa., March 15, 1884.
Ely, Charles Arthur, Elyria, Ohio (4).
Emerson, Geo. Barrell, Boston, Mass. (1). Born in Kennebunk, Me., Sept. 12, 1797. Died March 14, 1881.
Emmons, Ebenezer, Williamstown, Mass. (1). Born in Middlefield, Mass., May 16, 1799. Died October 1, 1863.
Engelmann, George, St. Louis, Mo. (1). Born in Frankfort-on-the Main, Germany, Feb. 2, 1809. Died Feb. 4, 1844.
Engstrom, A. B., Burlington, N. J. (1).
Eustis, Henry Lawrence, Cambridge, Mass. (2). Born Feb. 1, 1819. Died Jan. 11, 1885.
Evans, Edwin, Streator, Ill. (30). Died May 5, 1889.
Everett, Edward, Boston, Mass. (2). Born in Dorchester, Mass., April 11, 1794. Died in Boston, Mass., Jan. 15, 1865.
Ewing, Thomas, Lancaster, Ohio (5). Born in Ohio Co., Va., Dec. 28, 1789. Died Oct. 26, 1871.

Faries, R. J., Wauwatosa, Wis. (21). Died May 31, 1878.
Farquharson, Robert James, Des Moines, Iowa (24). Born July 15, 1824. Died Sept. 6, 1884.
Felton, Samuel Morse, Philadelphia, Pa. (29). Born in Newbury, Mass., July 19, 1809. Died in Philadelphia, Pa., Jan. 24, 1889.
Ferris, Isaac, New York, N. Y. (6). Born in New York, Oct. 9, 1798. Died in Roselle, N. J., June 16, 1873.
Feuchtwanger, Lewis, New York, N. Y. (11). Born in Fürth, Bavaria, Jan. 11, 1805. Died in New York, N. Y., June 25, 1876.
Ficklin, Joseph, Columbia, Mo. (20). Born in Winchester, Ky., Sept. 9, 1833. Died in Columbia, Mo., Sept. 6, 1887.
Fillmore, Millard, Buffalo, N. Y. (7). Born in New York, Jan. 7, 1800. Died March 8, 1874.
Fisher, Mark, Trenton, N. J. (10).
Fitch, Alexander, Hartford, Conn. (1). Born March 25, 1799. Died Jan. 20, 1859.
Fitch, O. H., Ashtabula, Ohio (7). Born in 1803. Died Sept. 17, 1882.
Foote, Herbert Carrington, Cleveland, Ohio (35). Born in 1852. Died in Cleveland, Aug. 24, 1888.
Forbush, E. B., Buffalo, N. Y. (15).

Force, Peter, Washington, D. C. (4). Born in New Jersey, Nov. 26, 1790. Died in Washington, D. C., Jan. 23, 1868.

Ford, A. C., Nashville, Tenn. (26).

Forshey, Caleb Goldsmith, New Orleans, La. (21). Born in Somerset Co., Pa., July 18, 1812. Died in Carrollton, La., July 25, 1881.

Foster, John Wells, Chicago, Ill. (1). Born in Brimfield, Mass., March 4, 1815. Died in Chicago, Ill., June 29, 1873.

Foucon, Felix, Madison, Wis. (18).

Fowle, Wm. Bentley, Boston, Mass. (1). Born in Boston, Mass., Oct. 17, 1795. Died Feb. 6, 1865.

Fox, Charles, Grosse Ile, Mich. (7).

Fox, Joseph G., Easton, Pa. (31). Born in Adams, N. Y., Sept. 7, 1833. Died in Easton, Pa., Dec. 27, 1889.

Frazer, John Fries, Phila., Pa. (1). Born July 8, 1812. Died Oct. 12, 1872.

Freeman, Spencer Hedden, Cleveland, Ohio (29). Born Oct. 8, 1855. Died Feb. 2, 1886.

French, John William, West Point, N. Y. (11). Born in Connecticut, about 1810. Died in West Point, N. Y., July 8, 1871.

Fuller, H. Weld, Boston, Mass. (29). Died Aug. 14, 1889.

Garber, A. P., Columbia, Pa. (29). Died Aug. 26, 1881.

Gardiner, Frederic, Middletown, Conn. (23). Born in Gardiner, Me., Oct. 22, 1822. Died in Middletown, Conn., July 17, 1889.

Gavit, John E., New York, N. Y. (1). Born in New York, Oct. 29, 1819. Died in Stockbridge, Mass., Aug. 25, 1874.

Gay, Martin, Boston, Mass. (1). Born in 1804. Died Jan. 12, 1850.

Gibbon, J. H., Charlotte, N. C. (3).

Gillespie, William Mitchell, Schenectady, N. Y. (10). Born in New York, N. Y., 1816. Died in New York, Jan. 1, 1868.

Gilmor, Robert, Baltimore, Md. (1).

Glazier, W. W., Key West, Fla. (29). Died Dec. 11, 1880.

Goldmark, J., New York, N. Y. (29). Died in April, 1882.

Gould, Augustus Addison, Boston, Mass. (11). Born April 23, 1805. Died Sept. 15, 1866.

Gould, Benjamin Apthorp, Boston, Mass. (2). Born in Lancaster, Mass., June 15, 1787. Died Oct. 24, 1859.

Graham, James D., Washington, D. C. (1). Born in Virginia, 1799. Died in Boston, Mass., Dec. 28, 1865.

Gray, Alonzo, Brooklyn, N. Y. (13). Born in Townshend, Vt., Feb. 21, 1808. Died in Brooklyn, N. Y., March 10, 1860.

Gray, Asa, Cambridge, Mass. (1). Born in Paris, N. Y., Nov. 18, 1810. Died in Cambridge, Mass., Jan. 30, 1888.

Gray, James H., Springfield, Mass. (6).

Greene, Benjamin D., Boston, Mass. (1). Died Oct. 14, 1862, aged 68.

Greene, Everett W., Madison, N. J. (10). Died in 1864.

Greene, Samuel, Woonsocket, R. I. (9). Died in 1868.

Greer, James, Dayton, Ohio (20). Died in Feb., 1874.

Griffith, Robert Eglesfield, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 13, 1798. Died June 26, 1854.

Griswold, John Augustus, Troy, N. Y. (19). Born Nov. 11, 1818. Died Oct. 31, 1872.

Guest, William E., Ogdensburg, N. Y. (6).

Guyot, Arnold, Princeton, N. J. (1). Born Sept. 5, 1809. Died Feb. 8, 1884.

Habel, Louis, Northfield, Vt. (34).

Hackley, Charles William, New York, N. Y. (4). Born in Herkimer Co., N. Y., March 9, 1809. Died in New York, N. Y., January 10, 1861.

Hadley, George, Buffalo, N. Y. (6). Born June, 1813. Died Oct. 16, 1877.

Haldeman, Samuel Stehman, Chickies, Pa. (1). Born Aug. 12, 1812. Died Sept. 10, 1880.

Hale, Enoch, Boston, Mass. (1). Born in Westhampton, Mass., Jan. 29, 1790. Died in Boston, Mass., Nov. 12, 1848.

Hamilton, Jno. M., Coudersport, Pa. (33).

Hampson, Thomas, Washington, D. C. (33).

Hance, Ebenezer, Fallsington P. O., Pa. (7). Died in 1876.

Harding, Myron H., Lawrenceburg, Ind. (30.) Died Sept., 1885.

Hare, Robert, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 17, 1781. Died in Philadelphia, May 15, 1858.

Harger, Oscar, New Haven, Conn. (25). Born in Oxford, Conn., Jan. 12, 1843. Died in New Haven, Conn., Nov. 6, 1887.

Harlan, Joseph G., Haverford, Pa. (8).

Harlan, Richard, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Sept. 19, 1796. Died in New Orleans, La., Sept. 30, 1843.

Harris, Thaddeus William, Cambridge, Mass. (1). Born in Dorchester, Mass., Nov. 12, 1795. Died in Cambridge, Mass., Jan. 16, 1856.

Harrison, A. M., Plymouth, Mass. (29).

Harrison, Benjamin Franklin, Wallingford, Conn. (11). Born April 19, 1811. Died April 23, 1886.

Harrison, Jos., jr., Philadelphia, Pa. (12). Born in Philadelphia, Pa., Sept. 20, 1810. Died in Philadelphia, March 27, 1874.

Hart, Simeon, Farmington, Conn. (1). Born Nov. 17, 1795. Died April 20, 1853.

Hartt, Charles Frederick, Ithaca, N. Y. (18). Born in Nova Scotia, Aug. 20, 1840. Died March 18, 1878.

Haven, Joseph, Chicago, Ill. (17). Born in Dennis, Mass., Jan. 4, 1816. Died May 23, 1874.

Hawes, George W., Washington, D. C. (23). Born Dec. 31, 1848. Died June 22, 1882.

Hayden, Ferdinand Vandeveer, Philadelphia, Pa. (29). Born in Westfield, Mass., Sept. 7, 1829. Died Dec. 22, 1887.

Hayden, Horace H., Baltimore, Md. (1). Born in Winsor, Conn., Oct. 13, 1769. Died in Baltimore, Md., Jan. 26, 1844.

Hayes, George E., Buffalo, N. Y. (15).

Hayward, James, Boston, Mass. (1). Born in Concord, Mass., June 12, 1786. Died in Boston, Mass., July 27, 1866.

Hazen, William Babcock, Washington, D. C. (30). Born in Hartford, Vt., Sept. 27, 1830. Died Jan. 16, 1887.

Hedrick, Benjamin Sherwood, Washington, D. C. (19). Born in 1826. Died Sept. 2, 1886.

Heighway, A. E., Cincinnati, Ohio (29). Born Dec. 26, 1820. Died Jan. 24, 1888.

Hempstead, G. S. B., Portsmouth, Ohio (29). Born in 1795. Died July 9, 1883.

Henry, Joseph, Washington, D. C. (1). Born in Albany, N. Y., Dec. 17, 1797. Died May 13, 1878.

Hickox, S. V. R., Chicago, Ill. (17). Died in 1872.

Hicks, William C., New York, N. Y. (34). Died in 1885.

Hilgard, Theodore Charles, St. Louis, Mo. (17). Born in Zweibrücken, Germany, Feb. 28, 1828. Died March 5, 1875.

Hill, Walter N., Chester, Pa. (29). Born Apr. 15, 1846. Died Mar. 29, 1884.

Hincks, William, Toronto, C. W. (11). Born in 1801. Died July, 1871.

Hitchcock, Edward, Amherst, Mass. (1). Born in Deerfield, Mass., May 24, 1793. Died Feb. 27, 1864.

Hoadley, John Chipman, Boston, Mass. (29). Born Dec. 10, 1818. Died Oct. 21, 1886.

Hodgson, W. B., Savannah, Ga. (10). Born 1815.

Holbrook, John Edwards, Charleston, S. C. (1). Born in Beaufort, S. C., Dec. 30, 1796. Died in Norfolk, Mass., Sept. 8, 1871.

Holman, Mrs. S. W., Boston, Mass. (29). Died May 5, 1885.

Holmes, Edward J., Boston, Mass. (29). Died in July, 1884.

Homes, Henry A., Albany, N. Y. (11). Born in Boston, Mass., March 10, 1812. Died in Albany, N. Y., Nov. 3, 1887.

Hopkins, Albert, Williamstown, Mass. (19). Born July 14, 1807. Died May 25, 1872.

Hopkins, James G., Ogdensburg, N. Y. (10). Died in 1860.

Hopkins, T. O., Williamsville, N. Y. (10). Died in 1866.

Hopkins, Wm., Lima, N. Y. (5). Died in March, 1867.

Hoppock, Albert E., Hastings-on-Hudson, N. Y. (29).

Horton, C. V. R., Chaumont, N. Y. (10). Died in 1862.

Horton, William, Craigville, N. Y. (1).

Hosford, Benj. F., Haverhill, Mass. (13). Died in 1864.

Hough, Franklin Benjamin, Lowville, N. Y. (4). Born in Martinsburgh, N. Y., July 20, 1822. Died June 11, 1885.

Houghton, Douglas, Detroit, Mich. (1). Born in Troy, N. Y., Sept. 21, 1809. Died Oct. 13, 1845.

Hovey, Edmund O., Crawfordsville, Ind. (20). Born July 15, 1801. Died March 10, 1877.

Howland, Edward Perry, Washington, D. C. (29). Born in Ledyard, N. Y., July 20, 1825. Died in Harrisburg, Pa., Sept. 12, 1888.

Hubbert, James, Richmond, Province of Quebec (16). Died in 1868.
Howland, Theodore, Buffalo, N. Y. (15).
Hunt, Edward Bissell, Washington, D. C. (2). Born in Livingston Co., N. Y., June 15, 1822. Died in Brooklyn, N. Y., Oct. 2, 1863.
Hunt, Freeman, New York, N. Y. (11). Born in Quincy, Mass., March 21, 1804. Died in Brooklyn, N. Y., March 2, 1858.
Hyatt, Theodore, Chester, Pa. (30).

Ives, Moses B., Providence, R. I. (9). Died in 1857.
Ives, Thomas P., Providence, R. I. (10).

Jackson, Charles Thomas, Boston, Mass. (1). Born in Plymouth, Mass., June 21, 1805. Died Aug. 28, 1880.
James, Thomas Potts, Cambridge, Mass. (22). Born Sept. 1, 1803. Died Feb. 22, 1882.
Johnson, Walter Rogers, Washington, D. C. (1). Born in Leominster, Mass., June 21, 1794. Died April 26, 1852.
Johnson, William Schuyler, Washington, D. C. (31). Born Sept. 20, 1859. Died Oct. 6, 1883.
Jones, Catesby A. R., Washington, D. C. (8).
Jones, Henry A., Portland, Me. (29). Died Sept. 3, 1883.
Jones, James H., Boston, Mass. (28).

Kedzie, W. K., Oberlin, Ohio (25). Born in Kalamazoo, Mich., July 5, 1851. Died in Lansing, Mich., Apr. 10, 1880.
Keely, George W., Waterville, Me. (1). Died in 1878.
Keep, N. C., Boston, Mass. (13). Died in March, 1875.
Kennicott, Robert, West Northfield, Ill. (12). Born Nov. 13, 1835. Died in 1866.
Kerr, Washington Caruthers, Raleigh, N. C. (10). Born May 24, 1827. Died Aug. 9, 1885.
Kidder, Henry Purkitt, Boston, Mass. (29). Born Jan. 3, 1823. Died Jan. 28, 1886.
King, Mitchell, Charleston, S. C. (3). Born in Scotland, June 8, 1783. Died Nov. 12, 1862.
Kirkpatrick, James A., Philadelphia, Pa. (7). Died June 3, 1886.
Kite, Thomas, Cincinnati, Ohio (5). Died Feb. 6, 1884.
Klippart, John H., Columbus, Ohio (17). Died October, 1878.
Knickerbocker, Charles, Chicago, Ill. (17). Died in 1873.
Knight, J. B., Philadelphia, Pa. (21). Died March 10, 1879.

Lacklan, R., Cincinnati, Ohio (11).
Lapham, Increase Allen, Milwaukee, Wis. (3). Born in Palmyra, N. Y., March 7, 1811. Died in Oconomowoc, Wis., Sept. 14, 1875.
Larkin, Ethan Pendleton, Alfred Centre, N. Y. (33). Born Sept. 20, 1829. Died Aug. 23, 1887.
LaRoche, Réné, Philadelphia, Pa. (12). Born in Philadelphia, Pa., 1795. Died in Philadelphia, Dec., 1872.

Lasel, Edward, Williamstown, Mass. (1). Born Jan. 21, 1809. Died Jan. 31, 1852.

Lawford, Frederick, Montreal, Canada (11). Died in 1866.

Lawrence, Edward, Charlestown, Mass. (18). Born June, 1810. Died Oct. 17, 1885.

Lea, Isaac, Philadelphia, Pa. (1). Born in Wilmington, Del., March 4, 1792. Died Dec. 8, 1886.

Le Conte, John Lawrence, Philadelphia, Pa. (1). Born in New York, May 13, 1825. Died Nov. 15, 1883.

Lederer, Baron von, Washington, D. C. (1).

Leonard, Rensselaer, Mauch Chunk, Pa. (33). Born in Hancock, N. Y., April 12, 1821. Died in Mauch Chunk, Pa., Oct. 26, 1888.

Lewis, Henry Carvill, Philadelphia, Pa. (26). Born in Philadelphia, Pa., Nov. 16, 1853. Died in Manchester, England, July 21, 1888.

Libbey, Joseph. Georgetown, D. C. (31). Died July 20, 1886.

Lieber, Oscar Montgomery, Columbia, S. C. (8). Born Sept. 8, 1830. Died June 27, 1862.

Lincklaen, Ledyard, Cazenovia, N. Y. (1). Born in Cazenovia, N. Y., Oct. 17, 1820. Died April 25, 1864.

Linsley, James Harvey, Stafford, Conn. (1). Born in Northford, Conn., May 5, 1787. Died in Stratford, Conn., Dec. 26, 1843.

Lockwood, Moses B., Providence, R. I. (9). Died in 1872.

Logan, William Edmond, Montreal, Canada (1). Born in Montreal, Canada, April 23, 1798. Died in Wales, June 22, 1875.

Loiseau, Emile F., Brussels, Belgium (33). Died April 30, 1886.

Loomis, Elias, New Haven, Conn. (1). Born in Willington, Conn., Aug. 7, 1811. Died in New Haven, Conn., Aug. 15, 1889.

Loosey, Charles F., New York, N. Y. (12).

Lothrop, Joshua R., Buffalo, N. Y. (15).

Lowrie, J. R., Warriorsmark, Pa. (29). Died Dec. 10, 1885.

Lull, Edward Phelps, Washington, D. C. (28). Born Feb. 20, 1836. Died March 5, 1887.

Lyford, Moses, Springfield, Mass. (22). Born in Mt. Vernon, Me., Jan. 31, 1816. Died in Portland, Me. Aug. 4, 1887.

Lyman, Chester Smith, New Haven, Conn. (4). Born in Manchester, Conn. Jan. 13, 1814, Died in New Haven, Conn., in 1889.

Lyon, Sidney S., Jeffersonville, Ind. (20). Born Aug. 4, 1808. Died June 24, 1872.

M'Conihe, Isaac, Troy, N. Y. (5).

McCutchen, A. R., Atlanta, Ga. (25). Died Nov. 21, 1887.

McElrath, Thomas, New York, N. Y. (36). Born in Williamsport, Pa., May 1, 1807. Died in New York, N. Y., June 6, 1888.

McFadden, Thomas, Westerville, Ohio (30). Born Nov. 9, 1825. Died Nov. 9, 1883.

McFarland, Walter, New York, N. Y. (36). Died July 22, 1888.

MacGregor, Donald, Houston, Texas (33). Died in Oct., 1887.

McLachlan, J. S., Montreal, Can. (31).
McMahon, Mathew, Albany, N. Y. (11).
Maack, G. A., Cambridge, Mass. (18). Died in Aug., 1873.
Macfarlane, James, Towanda, Pa. (29). Died in 1885.
Mahan, Dennis Hart, West Point, N. Y. (9). Born in New York, N. Y., April 2, 1802. Died in New York, Sept. 16, 1871.
Marler, George L., Montreal, Can. (31).
Marsh, Dexter, Greenfield, Mass. (1). Born in Montague, Mass., Aug. 22, 1806. Died in Greenfield, Mass., April 2, 1853.
Marsh, James E., Roxbury, Mass. (10).
Martin, Benjamin Nichols, New York, N. Y. (23). Born in Mount Holly, N. J., Oct. 20, 1816. Died in New York, N. Y., Dec. 26, 1883.
Mather, William Williams, Columbus, Ohio (1). Born in Brooklyn, Conn., May 24, 1804. Died in Columbus, Ohio, Feb. 27, 1859.
Maude, John B., St. Louis, Mo. (27). Died in April, 1879.
Maupin, S., Charlottesville, Va. (10).
May, Abigail Williams, Boston, Mass. (29). Born in Boston, April 21, 1829. Died in Boston, Nov. 30, 1888.
Meade, George Gordon, Philadelphia, Pa. (15). Born Dec. 30, 1815. Died Nov. 6, 1872.
Meek, Fielding Bradford, Washington, D. C. (6). Born Dec. 10, 1817. Died Dec. 21, 1876.
Meigs, James Aitken, Philadelphia, Pa. (12). Born July 30, 1829. Died Nov. 9, 1879.
Minifie, Wm., Baltimore, Md. (12). Born Aug. 14, 1805. Died Oct. 24, 1880.
Mitchel, Ormsby MacKnight, Cincinnati, Ohio (3). Born in Union Co., Ky., July 28, 1810. Died in Beaufort, S. C., Oct. 30, 1862.
Mitchell, Miss Maria, Lynn, Mass. (4). Born in Nantucket, Mass., Aug. 1, 1818. Died in Lynn, 1889.
Mitchell, William, Poughkeepsie, N. Y. (2). Born in Nantucket, Mass., Dec. 20, 1791. Died in Poughkeepsie, N. Y., April 19, 1868.
Mitchell, Wm. H., Florence, Ala. (17).
Monroe, Nathan, Bradford, Mass. (6). Born in Minot, Me., May 16, 1804. Died in Bradford, Mass., July 8, 1866.
Monroe, William, Concord, Mass. (18). Died April 27, 1877.
Morgan, Lewis Henry, Rochester, N. Y. (10). Born near Aurora, N. Y., Nov. 21, 1818. Died Dec. 17, 1881.
Morgan, Mrs. Mary E., Rochester, N. Y. (31). Died in 1884.
Morris, John B., Nashville, Tenn. (26).
Morton, Samuel George, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Jan. 26, 1799. Died in Philadelphia, May 15, 1851.
Mott, Alexander B., New York, N. Y. (36). Died Aug. 12, 1889.
Mudge, Benjamin Franklin, Manhattan, Kansas (25). Born in Orrington, Me., Aug. 11, 1817. Died Nov. 21, 1879.
Muir, William, Montreal, Can. (31). Died July, 1885.
Mussey, William Heberdom, Cincinnati, Ohio (30). Born Sept. 30, 1818. Died Aug. 1, 1882.

Nagel, Herman, St. Louis, Mo. (30). Born in Tritzwalk, Germany, May 28, 1820. Died in St. Louis, Mo., Feb. 18, 1889.

Newland, John, Saratoga Springs, N. Y. (28). Died Jan. 18, 1880.

Newton, E. H., Cambridge, N. Y. (1).

Nichols, Charles A., Providence, R. I. (17). Born Jan. 4, 1826. Died Oct. 20, 1877.

Nichols, William Ripley, Boston, Mass. (18). Born April 30, 1847. Died July 14, 1886.

Nicholson, Thomas, New Orleans, La. (21).

Nicollet, Jean Nicholas, Washington, D. C. (1). Born in Savoy, France, July 24, 1786. Died in Washington, D. C., Sept. 11, 1843.

Norton, John Pitkin, New Haven, Conn. (1). Born July 19, 1822. Died Sept. 5, 1852.

Norton, William Augustus, New Haven, Conn. (6). Born in East Bloomfield, N. Y., Oct. 25, 1810. Died Sept. 21, 1883.

Noyes, James Oscar, New Orleans, La. (21). Born in Niles, N. Y., June 14, 1829. Died in New Orleans, La., Sept. 11, 1872.

Nutt, Cyrus, Bloomington, Ind. (20). Born in Trumbull Co., Ohio, Sept. 4, 1814. Died in Bloomington, Aug. 23, 1875.

Oakes, Wm., Ipswich, Mass. (1). Born July 1, 1799. Died July 31, 1848.

Ogden, Robert W., New Orleans, La. (21). Died March 24, 1878.

Ogden, William Butler, High Bridge, N. Y. (17). Born in New York, N. Y., 1805. Died in New York, Aug. 3, 1877.

Oliver, Miss Mary E., Ithaca, N. Y. (20).

Olmsted, Alexander Fisher, New Haven, Conn. (4). Born Dec. 20, 1822. Died May 5, 1853.

Olmsted, Denison, New Haven, Conn. (1). Born in East Hartford, Conn., June 18, 1791. Died in New Haven, Conn., May 13, 1859.

Olmsted, Denison, jr., New Haven, Conn. (1). Born Feb. 16, 1824. Died Aug. 15, 1846.

Orton, James, Poughkeepsie, N. Y. (18). Born in Seneca Falls, N. Y., April 21, 1830. Died in Peru, S. A., Sept. 24, 1877.

Osbun, Isaac J., Salem, Mass. (29).

Otis, George Alexander, Washington, D. C. (10). Born in Boston, Mass., Nov. 12, 1830. Died Feb. 23, 1881.

Owen, Richard, New Harmony, Ind. (20). Born in Scotland, Jan. 6, 1810. Died in New Harmony, March 24, 1890.

Packer, Harry E., Mauch Chunk, Pa. (30). Died Feb. 1, 1884.

Painter, Jacob, Lima, Pa. (23). Died in 1876.

Painter, Minshall, Lima, Pa. (7).

Parker, Wilbur F., West Meriden, Conn. (23). Died in 1876.

Parkman, Samuel, Boston, Mass. (1). Born in 1816. Died Dec. 15, 1854.

Parry, Charles C., Davenport, Iowa (6). Born in Admington, Worcestershire, Eng., Aug. 28, 1823. Died in Davenport, Iowa, Feb. 20, 1890.

Parsons, Henry Betts, New York, N. Y. (30). Born Nov. 20, 1855. Died Aug. 21, 1885.

Payn, Charles H., Saratoga Springs, N. Y. (28). Born May 16, 1814. Died Dec. 20, 1881.

Peirce, Benjamin Osgood, Beverly, Mass. (18). Born in Beverly, Sept. 26, 1812. Died in Beverly, Nov. 12, 1883.

Peirce, Benjamin, Cambridge, Mass. (1). Born in Salem, Mass., April 4, 1809. Died in Cambridge, Mass., Oct. 6, 1880.

Perch, Bernard, Frankford, Pa. (35). Born in 1850. Died in 1887.

Perkins, George Roberts, Utica, N. Y. (1). Born in Otsego Co., N. Y., May 3, 1812. Died in New Hartford, N. Y., Aug. 22, 1876.

Perkins, Henry C., Newburyport, Mass. (18). Born Nov. 13, 1804. Died Feb. 2, 1873.

Perry, John B., Cambridge, Mass. (16). Born in 1820. Died Oct. 3, 1872.

Perry, Matthew Calbraith, New York, N. Y. (10). Born in South Kingston, R. I., 1795. Died in New York, March 4, 1858.

Phelps, Mrs. Almira Hart Lincoln, Baltimore, Md. (13). Born in Berlin, Conn., July 15, 1793. Died in Berlin, July 15, 1884.

Philbrick, Edw. S., Brookline, Mass. (29). Born in Boston, Mass., Nov. 20, 1827. Died in Brookline, Mass., Feb. 13, 1889.

Phillips, John C., Boston, Mass. (29). Born in 1839. Died Mar. 1, 1885.

Piggot, A. Snowden, Baltimore, Md. (10).

Pim, Bedford Clapperton Trevelyan, London, Eng. (33). Born in England, June 12, 1826. Died Oct., 1886.

Platt, W. G., Philadelphia, Pa. (32). Died Nov., 1885.

Plumb, Ovid, Salisbury, Conn. (9).

Pope, Charles Alexander, St. Louis, Mo. (12). Born in Huntsville, Ala., March 15, 1818. Died in Paris, Mo., July 6, 1870.

Porter, John Addison, New Haven, Conn. (14). Born in Catskill, N. Y., March 15, 1822. Died in New Haven, Conn., Aug. 25, 1866.

Potter, Stephen H., Hamilton, Ohio (30). Born Nov. 10, 1812. Died Dec. 9, 1883.

Pourtalès, Louis François de, Cambridge, Mass. (1). Born March 4, 1824. Died July 19, 1880.

Pruyn, John Van Schaick Lansing, Albany, N. Y. (1). Born in Albany, N. Y. June 22, 1811. Died in Clifton Springs, N. Y., Nov. 21, 1877.

Pugh, Evan, Centre Co., Pa. (14). Born Feb. 29, 1828. Died April 29, 1864.

Pulsifer, Sidney, Philadelphia, Pa. (21). Died March 24, 1884.

Putnam, Mrs. Frederick Ward, Cambridge, Mass. (19). Born in Charlestown, Mass., Dec. 29, 1838. Died in Cambridge, Mass., March 10, 1879.

Putnam, J. Duncan, Davenport, Iowa (27). Born Oct. 18, 1855. Died Dec. 10, 1881.

Read, Ezra, Terre Haute, Ind. (20). Died in 1877.

Redfield, William C., New York, N. Y. (1). Born near Middletown, Conn., March 26, 1789. Died Feb. 12, 1857.

Resor, Jacob, Cincinnati, Ohio (8). Died in 1871.

Robb, James, Fredericton, N. B. (4).

Robinson, Coleman T., Buffalo, N. Y. (15). Born in Putnam Co., N. Y. in 1888. Died near Brewster's Station, N. Y., May 1, 1872.

Rochester, Thomas Fortescue, Buffalo, N. Y. (35). Born Oct. 8, 1823. Died May 24, 1887.

Rockwell, John Arnold, Norwich, Conn. (10). Born in Norwich, Conn., August 27, 1803. Died in Washington, D. C., February 10, 1861.

Roeder, F. A., Cincinnati, Ohio (30).

Rogers, Henry Darwin, Glasgow, Scotland (1). Born in Philadelphia, Pa., Aug. 1, 1808. Died in Glasgow, Scotland, May 29, 1866.

Rogers, James Blythe, Philadelphia, Pa. (1). Born in Philadelphia, Pa., Feb. 11, 1802. Died in Philadelphia, June 15, 1852.

Rogers, Robert Empie, Philadelphia, Pa. (18). Born in Baltimore, Md., March 29, 1813. Died Sept. 6, 1884.

Rogers, William Barton, Boston, Mass. (1). Born in Philadelphia, Pa, Dec. 7, 1804. Died in Boston, May 30, 1882.

Root, Elihu, Amherst, Mass. (25). Born Sept. 14, 1845.

Sager, Abram, Ann Arbor, Mich. (6). Born in Bethlehem, N. Y., Dec. 22, 1811. Died August 6, 1877.

Sanders, Benjamin D., Wellsburg, W. Va. (19).

Scammon, Jonathan Young, Chicago, Ill. (17). Born in Whitefield, Me. in 1812. Died in Chicago, Ill., March 17, 1890.

Schaeffer, Geo. C., Washington, D. C. (1). Died in 1873.

Schley, William, New York, N. Y. (28). Died in 1882.

Schram, Nicholas Hallock, Newburgh, N. Y. (33). Died in Newburgh, N. Y., aged 54 years, 1 month and 2 days.

Scott, Joseph, Dunham, C. E. (11). Died in 1865.

Seaman, Ezra Champion, Ann Arbor, Mich. (20). Born Oct. 14, 1805. Died July 15, 1880.

Senecal, L. A., Montreal, Can. (31).

Senter, Harvey S., Aledo, Ill. (20). Died in 1875.

Seward, William Henry, Auburn, N. Y. (1). Born in Florida, N. Y., May 16, 1801. Died in Auburn, N. Y., Oct. 10, 1872.

Sheppard, William, Drummondville, Province of Quebec, Can. (11). Born in 1783. Died in 1867.

Sherwin, Thomas, Dedham, Mass. (11). Born in Westmoreland, N. H., March 26, 1799. Died in Dedham, Mass., July 23, 1869.

Sill, Elisha N., Cuyahoga Falls, Ohio (6). Born in 1801. Died April 26, 1888.

Silliman, Benjamin, New Haven, Conn. (1). Born in North Stratford, Conn., August 8, 1779. Died in New Haven, Conn., Nov. 22, 1864.

Silliman, Benjamin, New Haven, Conn. (1). Born in New Haven, Conn., Dec. 4, 1816. Died Jan. 14, 1885.

Simpson, Edward, Washington, D. C. (28). Born in New York, N. Y., March 3, 1824. Died in Washington, D. C., Dec. 1, 1888.

Skinner, George, Kalida, Ohio (33).

Skinner, John B., Buffalo, N. Y. (15). Died in 1871.

Slack, J. H., Philadelphia, Pa. (12).

Smith, Charles A., St. Louis, Mo. (27). Died in 1884.

Smith, David P., Springfield, Mass. (29). Born Oct. 1, 1830. Died Dec. 26, 1880.

Smith, Mrs. Erminnie Adelle, Jersey City, N. J. (25). Born April 26, 1836. Died June 9, 1886.

Smith, John Lawrence, Louisville, Ky. (1). Born near Charleston, S. C., Dec. 17, 1818. Died Oct. 12, 1883.

Smith, J. V., Cincinnati, Ohio (5).

Smith, James Young, Providence, R. I. (9). Born in Groton, Conn., Sept. 15, 1809. Died March 26, 1876.

Smith, Lyndon Arnold, Newark, N. J. (9). Born in Haverhill, N. H., November 11, 1795. Died in Newark, N. J., December 15, 1865.

Snell, Ebenezer Strong, Amherst, Mass. (2). Born in North Brookfield, Mass., October 7, 1801. Died in Amherst, Mass., Sept., 1877.

Sparks, Jared, Cambridge, Mass. (2). Born in Willington, Conn., May 10, 1819. Died in Cambridge, Mass., March 14, 1866.

Spinzig, Charles, St. Louis, Mo. (27). Died Jan. 22, 1882.

Squier, Ephraim George, New York, N. Y. (18). Born in Bethlehem, N. Y., June 17, 1821. Died in Brooklyn, N. Y., April 17, 1888.

Stearns, Josiah A., Boston, Mass. (29).

Stearns, Silas, Pensacola, Fla. (28). Died Aug. 2, 1888.

Steele, Joel Dorman, Elmira, N. Y. (33). Born in Lima, N. Y., May 14, 1836. Died May 25, 1886.

Stevenson, James, Washington, D. C. (29). Born in Maysville, Ky., Dec. 24, 1840. Died in New York, N. Y., July 23, 1888.

Stimpson, Wm., Chicago, Ill. (12). Born Feb. 14, 1832. Died May 26, 1872.

Stone, Leander, Chicago, Ill. (32). Died April 2, 1888.

Stone, Samuel, Chicago, Ill. (17). Born Dec. 6, 1798. Died May 4, 1876.

St. John, Joseph S., Albany, N. Y. (28). Died Nov. 23, 1882.

Straight, H. H., Chicago, Ill. (25). Died Nov. 17, 1886.

Sullivan, Algernon Sidney, New York, N. Y. (36). Born April 5, 1826. Died Dec. 4, 1887.

Sullivant, William Starling, Columbus, Ohio (7). Born near Columbus, O., Jan 15, 1803. Died in Columbus, O., April 30, 1873.

Sutton, George, Aurora, Ind. (20.) Died June 13, 1886.

Swain, James, Fort Dodge, Iowa (21). Born in 1816. Died in 1877.

Tallmadge, James, New York, N. Y. (1). Born in Stamford, N. Y., Jan. 20, 1778. Died in New York, N. Y., Oct. 8, 1853.

Taylor, Arthur F., Cleveland, Ohio (29). Born Dec. 10, 1853. Died June 28, 1883.

Taylor, Richard Cowling, Philadelphia, Pa. (1). Born in England, Jan. 18, 1789. Died in Philadelphia, Pa., November 26, 1851.

Taylor, Robert N., Tollesboro, Ky. (37). Died Aug. 13, 1888.

Tenney, Sanborn, Williamstown, Mass. (17). Born in January, 1827. Died July 11, 1877.

Teschemacher, James Englebert, Boston, Mass. (1). Born in Nottingham, England, June 11, 1790. Died near Boston, Nov. 9, 1853.

Thompson, A. Remsen, New York, N. Y. (1). Died in Oct., 1879.

Thompson, Alexander, Aurora, N. Y. (1).

Thompson, Charles Oliver, Terre Haute, Ind. (29). Born in East Windsor Hill, Conn., Sept. 25, 1835. Died in Terre Haute, Ind., March 17, 1885.

Thompson, Zadock, Burlington, Vt. (1). Born in Bridgewater, Vt., May 23, 1796. Died in Burlington, Vt, Jan 19, 1856.

Thomson, Henry R., Crawfordsville, Ind. (30). Died in 1884.

Thurber, Isaac, Providence, R. I. (9).

Tileman, John Nicholas, Sandy, Utah (33). Born in Hothun, Denmark, March 28, 1845. Died in Salt Lake City, Utah, Sept. 4, 1888.

Tillman, Samuel Dyer, Jersey City, N. J. (15). Born April, 1815. Died Sept. 4, 1875.

Tobin, Thomas W., Louisville, Ky. (30). Died Aug. 4, 1883.

Todd, Albert, St. Louis, Mo. (27). Born March 4, 1813. Died April 30, 1885.

Tolderoy, James B., Fredericton, N. B. (11).

Torrey, John, New York, N. Y. (1). Born in New York, N. Y., Aug. 15, 1796. Died in New York, March 10, 1873.

Torrey, Joseph, Burlington, Vt. (2). Born in Rowley, Mass., Feb. 2, 1797. Died in Burlington, Vt., Nov. 26, 1867.

Totten, Joseph Gilbert, Washington, D. C. (1). Born in New Haven, Conn., August 23, 1788. Died in Washington, D. C., April 22, 1864.

Townsend, Howard, Albany, N. Y. (10). Born Nov. 22, 1823. Died Jan. 6, 1867.

Townsend, John Kirk, Philadelphia, Pa. (1). Born Aug. 10, 1809. Died Feb. 16, 1851.

Townsend, Robert, Albany, N. Y. (9). Born 1799. Died Aug. 15, 1866.

Troost, Gerard, Nashville, Tenn. (1). Born in Bois-le-Duc, Holland, March 15, 1776. Died in Nashville, Tenn., Aug. 14, 1850.

Tuomey, Michael, Tuscaloosa, Ala. (1). Born in Ireland, September 29, 1805. Died in Tuscaloosa, Ala., March 20, 1857.

Tweedale, John B., St. Thomas, Can. (35). Born in Ormskirk, Lancashire, Eng., Oct. 16, 1821. Died in St. Thomas, Can., Nov. 18, 1889.

Tyler, Edward R., New Haven, Conn. (1). Born Aug. 3, 1800. Died Sept. 28, 1848.

Vancleve, John W., Dayton, Ohio (1).

Vanuxem, Lardner, Bristol, Pa. (1). Born in Philadelphia, Pa., July 23, 1792. Died in Bristol, Pa., June 25, 1848.

Vaux, William Sanson, Philadelphia, Pa. (1). Born in Philadelphia, May 19, 1811. Died in Philadelphia, May 5, 1882.

Wadsworth, James Samuel, Genesee, N. Y. (2). Born in Geneseo, N. Y., October 30, 1807. Died near Chancellorville, Va., May 8, 1864.

Wagner, Tobias, Philadelphia, Pa. (9).

Walker, J. R., Bay Saint Louis, Miss. (19). Born Aug. 7, 1830. Died June 22, 1887.

Walker, Joseph, Oxford, N. Y. (10).

Walker, Sears C., Washington, D. C. (1). Born March 28, 1805. Died January 30, 1853.

Walker, Timothy, Cincinnati, Ohio (4). Born in Wilmington, Mass., Dec. 1, 1802. Died in Cincinnati, Ohio, Jan. 15, 1856.

Walling, H. F., Cambridge, Mass. (16). Died April 8, 1888.

Walsh, Benjamin D., Rock Island, Ill. (17). Born in Frome, England, Sept. 21, 1808. Died in Rock Island, Ill., Nov. 18, 1869.

Wanzer, Ira, Brookfield, Conn. (18). Born April 17, 1796. Died March 5, 1879.

Warnecke, Carl, Montreal, Can. (31). Died May 14, 1886.

Warren, Geo. Washington, Boston, Mass. (18). Died in 1884.

Warren, Gouverneur Kemble, Newport, R. I. (12). Born in Cold Spring N. Y., Jan. 8, 1830. Died in Newport, R. I., Aug. 8, 1882.

Warren, John Collins, Boston, Mass. (1). Born in Boston, Mass., Aug. 1, 1778. Died in Boston, May 4, 1856.

Warren, Samuel D., Boston, Mass. (29). Born in 1817. Died May 11, 1888.

Watertown, Charles, Wakefield, Eng. (1). Born in Wakefield, England. Died in Wakefield, May 26, 1865.

Watkins, Samuel, Nashville, Tenn. (26).

Watson, James Craig, Ann Arbor, Mich. (13). Born in Fingal, Canada, Jan. 28, 1838. Died in Madison, Wis., Nov. 23, 1880.

Webster, Horace B., Albany, N. Y. (1). Born in 1812. Died Dec. 8, 1843.

Webster, J. W., Cambridge, Mass. (1). Born in 1793. Died Aug. 30, 1850.

Webster, M. H., Albany, N. Y. (1).

Weed, Monroe, Wyoming, N. Y. (6). Died in 1867.

Welch, Mrs. G. O., Lynn, Mass. (21). Died in June, 1882.

Welsh, John, Philadelphia, Pa. (33). Died May, 1886.

Weyman, George W., Pittsburgh, Pa. (6). Born April, 1832. Died July 16, 1864.

Wheatland, Richard H., Salem, Mass. (13). Born July 6, 1830. Died Dec. 21, 1863.

Wheatley, Charles M., Phœnixville, Pa. (1). Died May 6, 1882.

Wheeler, Arthur W., Baltimore, Md. (29). Born in March, 1859. Died Jan. 6, 1881.

Whitall, Henry, Camden, N. J. (33).

White, Samuel S., Philadelphia, Pa. (23). Died Dec. 30, 1879.

Whiting, Lewis E., Saratoga Springs, N. Y. (28). Born March 7, 1815. Died Aug. 2, 1882.

Whitman, Edmund B., Cambridge, Mass. (29). Died Sept. 2, 1883.

Whitman, Wm. E., Philadelphia, Pa. (23). Died in 1875.

Whitney, Asa, Philadelphia, Pa. (1). Born Dec. 1, 1791. Died June 4, 1874.

Whittlesey, Charles, Cleveland, Ohio (1). Born in Southington, Conn., Oct. 5, 1808. Died Oct. 18, 1886.

Whittlesey, Charles C., St. Louis, Mo. (11). Died in 1872.

Wight, Orlando W., Detroit, Mich. (34).

Wilber, G. M., Pine Plains, N. Y. (19).

Wilder, Graham, Louisville, Ky. (30). Born July 1, 1843. Died Jan. 16, 1885.

Willard, Emma C. Hart, Troy, N. Y. (15). Born in Berlin, Conn., Feb. 23, 1787. Died in Troy, N. Y., April 15, 1870.

Williams, Frank, Buffalo, N. Y. (25). Died Aug. 13, 1884.

Williams, P. O., Watertown, N. Y. (24).

Williamson, Robert S., San Francisco, Cal. (12). Born in New York about 1825.

Wilson, C. H., Belize, British Honduras (30).

Wilson, Mrs. Mary V. C., Mobile, Ala. (37). Born in Morengo County, Ala., Jan. 29, 1840. Died near Tullahoma, Tenn., June 24, 1889.

Wilson, W. C., Carlisle, Pa. (12).

Winlock, Joseph, Cambridge, Mass. (5). Born in Shelbyville, Ky., Feb. 6, 1826. Died in Cambridge, Mass., June 11, 1875.

Woerd, Chas. Vander, Waltham, Mass. (29). Born in Leyden, Holland, Oct. 6, 1821. Died near Dagget, Cal., Dec. 29, 1888.

Woodbury, Levi, Portsmouth, N. H. (1). Born in Francistown, N. H., Dec. 22, 1789. Died Sept. 4, 1851.

Woodman, John Smith, Hanover, N. H. (11). Born in Durham, N. H., Sept. 6, 1819. Died in Durham, N. H., May 15, 1871.

Woodward, Joseph Janvier, Washington, D. C. (28). Born in Philadelphia, Pa., Oct. 30, 1833. Died near that city, Aug. 17, 1884.

Worthen, Amos Henry, Springfield, Ill. (5). Born Oct. 31, 1813. Died May 6, 1888.

Wright, Elizur, Boston, Mass. (31). Born in South Canaan, Conn., Feb. 12, 1804. Died Nov. 20, 1885.

Wright, Harrison, Wilkes Barre, Pa. (29). Born July 15, 1850. Died Feb. 20, 1885.

Wright, John, Troy, N. Y. (1).

Wyman, Jeffries, Cambridge, Mass. (1). Born in Chelmsford, Mass., Aug. 11, 1814. Died in Bethlehem, N. H., Sept. 4, 1874.

Wyckoff, William Cornelius, New York, N. Y. (20). Born in New York, N. Y., May 28, 1832. Died in Brooklyn, N. Y., May 2, 1888.

Yarnall, M., Washington, D. C. (26). Born in 1817. Died Jan. 27, 1879.

Youmans, Edward Livingston, New York, N. Y. (6). Born in Coeymans, N. Y., June 3, 1821. Died Jan. 18, 1887.

Young, Ira, Hanover, N. H. (1). Born in Lebanon, N. H., May 23, 1801. Died in Hanover, N. H., Sept. 14, 1858.

Zentmayer, Joseph, Philadelphia, Pa. (29). Died, 1887.

ADDRESS

BY

J. W. POWELL,

THE RETIRING PRESIDENT OF THE ASSOCIATION.

EVOLUTION OF MUSIC FROM DANCE TO SYMPHONY.

A BLUE egg may become a robin. The latent life sequestered by marble walls may be warmed into activity and gather to itself the crumbs from a cottage table and weave therefrom the tissues of life — feet to perch among the blossoms, wings to fly among the trees, eyes to revel in the scenes disclosed by sunlight, and vocal organs to sing the song of love to mate.

A tiny seed may become a "big tree," for, warmed into life, it sends its rootlets into the nourishing earth and its branches into the vivifying air, and gathers materials with which to build a sequoyah, that stands for centuries as a glory in the forest of the sierra.

The rill born of a summer shower carries the sand from the hillside and gives it to the brook, and the brook bears it on to the river, and the river transports it to the sea, and the impregnated tide finds a nest beneath the waves and in it lays the egg of an island. Then this boss on the floor of the ocean has the power to gather about it more sands as they come from the distant hills, and still more sands. Every summer shower gives it more, and every storm adds to the sands that are thus buried beneath the sea, until at last an island is hatched, as it lifts its head above the waves.

Robins grow to be robins by minute increments; trees grow to be trees by minute increments; islands grow to be islands by minute increments. There is an aphorism current in the world that

like begets its like; it is but half the truth. Whatever is, changes, and no repetition comes through all the years of time; some minute change must ever intervene. Among living things one generation follows another, always with some change, and change on change in sequent reproduction as the stream of life flows on, results at last in transformation. This slow but sure metamorphosis is called evolution, and the scientific world is engaged in the formulation of its laws.

The laws of animal and vegetal progress, otherwise called biotic evolution, do not apply to mankind in civilization. Biotic evolution is progress in bodily function; human evolution is progress in culture. The one is dependent on the laws of vitality, the other dependent on the laws of psychology. The first great law of biotic evolution is denominated *the survival of the fittest in the struggle for existence*. This law does not directly apply to man in his progress in culture. The bad are not killed off by any natural process in order that the good may survive and propagate their kind. Human progress is by human endeavor, by conscious and designed effort for improvement in condition.

The second great law in biotic evolution is denominated *adaptation to environment*. But man is not adapted to environment. He adapts the environment to himself by creating that which he desires. For example, no natural protection to his body is developed by which he is adapted to a boreal climate, but he adapts that climate to himself, modifies it in its effect upon himself by building a house and creating a home climate at the fireside. And when outside of his home, he protects himself with clothing and creates a personal climate and laughs at the winds that drift the snow. Man is not adapted to environment, but he adapts his arts to environment, and creates new conditions to please himself.

The third great law of biotic evolution is denominated *progress in heterogeneity*. With time animals become more and more diverse in structure and function. Kinds or species multiply. But this law is reversed with men in civilization, for they become more and more homogeneous. The tendency is not to differentiate into species, some with horns and hoofs, some with tusks and claws and some with arms and some with wings. The tendency is not towards specific differentiation, but towards specific homogeneity.

There is, however, another kind of differentiation that develops by culture, which may be denominated *qualitative differentiation*.

Human beings do not develop along divergent lines, but along parallel lines, and they differ mainly in the degree in which they have made progress. Human evolution develops not different kinds of men, but different qualities of men. The apple tree under human culture does not develop in one line to bear peaches, another to bear plums and another to bear pine-apples. But the fruit of one tree is sour and that of another is sweet. One is dwarfed, gnarled and bitter, another is large, roseate and luscious. Human progress is such culture. It develops different qualities and degrees of the same thing. There are apple trees that bear nothing but sorry fruits. There are tribes of the world that are all savages. The trees of higher culture bear fruits of diverse qualities. The well-developed pippin, the diseased pippin and the shrivelled knot of bitterness grow on the same tree. So in lands of highest culture men are good and bad, wise and unwise, but they do not thus become specifically different.

The fourth great law of biotic evolution is denominated *progress in integration.* The differentiating parts also become more and more interdependent. The organ which can best subserve its purpose is less efficient in performing an unwonted function; it therefore becomes dependent upon other organs, and the interdependence of all the parts of the same organism increases with evolution. Society is an organism. The people organized as a body-politic and constituting a nation become interdependent, and each one is interested in the common welfare. In the growth of society through the organization of kindred into clans, and of clans into tribes, and ultimately of tribes into nations, great progress in integration is made, and it receives its highest development when despotism is organized. If we study the progress of society through these stages only, we are led to conclude that biotic evolution and human culture follow the same laws, for the integration of mankind in despotic nations is measured by the perfection of despotic governments. The highest integration is secured with hereditary rulers, privileged classes and enslaved common people.

The progress of mankind from despotism to liberty has been one vast system of warfare against integration, until in perfect liberty under free institutions this integration is destroyed, and the biotic law is repealed in its application to mankind. The development of liberty is the overthrow of the fourth law of animal evolution.

Liberty means freedom to the individual and is secured by es-

tablishing interdependence of industries; thus man transfers despotism from himself to his inventions.

No cruel law of destruction belongs to mankind. No brutal adaptation to environments occurs in the course of human culture. No differentiation into antagonistic species is found. And liberty destroys despotic integration.

The laws of biotic evolution do not apply to mankind. There are men in the world so overwhelmed with the grandeur and truth of biotic evolution that they actually believe that man is but a two-legged beast whose progress in the world is governed by the same laws as the progress of the serpent or the wolf; and so science is put to shame.

Since the doctrines of evolution have been established, the basis of systematic classification has been changed. Artificial categories have given place to natural categories in such a manner that the classes are believed to represent genetic relations. The search for natural categories began anterior to the establishment of the laws of biotic evolution, and the new philosophy would be unrecognized but for the work which systematic biology has already done. Natural classifications and the laws of hereditary descent develop together and are interdependently established. Still it remains that genetic biology, or the science of the laws of the progress of life, imposes conditions upon systematic biology, for a natural classification must reveal the fundamental epochs and phases of evolution.

As human progress is not upon divergent lines, but upon the same line to the goal of a higher life, men must be classified not by biotic kinds, but by degrees of culture; and the three great culture stages, not three great kinds of men, be it understood, have been called savagery, barbarism and civilization, to which a fourth may well be added, that of modern civilization,— the stage of enlightenment.

That which makes man more than the beast is culture. Culture is human evolution; not the development of man as an animal, but the evolution of the human attributes of man. Culture is the product of human endeavor. This is the burden of my argument.

In man's progress from savagery to enlightenment, he has transferred the laws of beast evolution from himself to his inventions and, relieved of the load, he has soared away to the goal of his destiny on the wings of higher laws.

The evolution of music has been presented as an illustration of this fact. Man as a poet has not developed by the survival of the fittest. There has been no natural system of laws by which the bad musician has been killed and the good musician permitted to live and propagate his kind. There has been no system of natural selection to kill poor singers and cheap fiddlers.

There is no adaptation of musicians to environment. There are no aquatic musicians; there are no aërial musicians; there are no tropical musicians; there are no boreal musicians as those terms are used in biology. The prima donna that sings in Rome may sing in St. Petersburg. The artist on the violin may enrapture the people in Toronto, in Washington, or in Mexico, and an orchestra may play on the land and on the sea.

Again there has been no progress in the differentiation of musicians. There is no musical species. There is no distinct race of prima-donnas. There is no endogenous clan of organists. Musical folk spring up among the people everywhere. Of two children of the same parents, the one will be musical and the other will not be. A sister will play the violin with beauty and a brother may love nothing better than an accordeon.

Every nation and tribe on the face of the earth has developed its own musicians, and when a great artist springs up in any land he travels the world and delights all the people of civilization. Ole Bull like Orpheus would make the stony hearts of all men dance, and Jenny Lind could sing a song of sorrow to weeping multitudes in any city of Christendom, and if the angels loved not her music small be the meed of praise for angels.

And, lastly, there is no integration of musicians. They are not organized into one body-politic. They do not inhabit one little nook of the world. They are not gathered by themselves on one isle of the sea. The king of players is metaphoric king, the queen of singers is metaphoric queen.

But though these laws of evolution do not apply to musicians, they yet do apply to music itself. Man has transferred them from himself to his musical inventions. Ever there has been a survival of the fittest. The music of savagery is lost in barbarism. The songs of barbarism are lost in civilization, and modern music is replacing the music of our fathers. So the old grows into the new by the survival of the fittest; not by natural selection, but by human selection, for men choose to keep the music they love the best.

There has been progress by differentiation in music. Gradually music has developed into distinct parts, and with the invention of musical instruments, musical compositions have been produced adapted to each. There is the music of the organ, the piano, the flute, the violin, and instruments too many to tell, and thus the world is filled with varied music.

Music has been adapted to environment. There is music for the dance, and for the battle; music for the wedding, and the funeral; music for the theatre and the temple; and there is music about everything: the land, the sea and the air, the valley and the mountain, the flower and the forest, the fountain and the river, the worm and the serpent, the zephyr and the tempest. There is music for all peoples in all climes, in all conditions; the varieties of music parallel every human thought.

There is integration of music. When a band plays organized music for the military parade, many instruments combine to play their parts in harmony. There is organized music for the temple where the choir and the instruments combine to make music for prayer and praise. But the highest development of musical integration is found in the orchestra where the parts of the symphony are played in sweet unison, in grand harmony and sublime sequence, guided by the magic baton of the leader.

Music is the invention of mankind, not of one man, but of all men, of composers, performers and hearers. Music has come down the stream of time, and as the rivers grow from source to sea, so music grows from primal time to vast eternity.

In the same manner we may take up any one of the elements of human culture and develop the laws of its evolution and find that all culture comes by human endeavor. All arts, all institutions, all languages, all opinions, have grown in obedience to the laws of evolution as set forth, and in the exercise of all these human activities man himself has been developed; so the laws of biotic evolution apply not to mankind. Beast is beast, man is man.

I have affirmed that the laws of biotic evolution do not apply to human culture; to make this clear, concrete demonstration is necessary. On this occasion one of the æsthetic arts will be used for this purpose; the evolution of music will be portrayed and its laws developed, and it will be followed briefly through the four stages of culture: savagery, barbarism, civilization and enlightenment.

The classific categories of biology should represent genesis by differentiation, but it has been shown that man cannot thus be classified. Man by his genius has transferred the application of the four great laws of biotic evolution from himself to his inventions. Human inventions evolve by human selection, and there is a survival of the fittest, an adaptation to environment, a progress in differentiation, and a progress in integration. Human inventions, therefore, should be classified in such a manner as to exhibit their genesis by differentiation.

If we classify the fine arts on these principles we must place them in four groups, as we find them arising from four germs. It is true that their development has been more or less interdependent, yet they have four origins and have developed along four lines, both in form and motive.

Fetich carving was the germ of sculpture. Stone, bone, shell, wood, and various other materials were used by the sculptor in which to carve the forms of his beast gods. Carving begun in this rude way developed at last along two lines, one leading to idolatry, and the other to sculpture.

Picture-writing was the germ of painting. Early man daubed rude pictures on bark and other materials and etched them on stone. The alphabetic arts also sprang from this source, as writing, printing and telegraphing.

Mythology was the germ of drama. Early man believed the animals to be the creators and movers of his universe and the stories of the doings of beasts constituted the first drama. Later romance sprang from the same source, and from romance biography and history. Along another line from the same germ sprang science.

The dance was the germ of music and poetry. Poetry derived its form from the dance and its earliest motive from mythology. The evolution of music will be set forth more fully.

Sculpture represents material forms in solid matter, as wood, clay, stone, ivory and metal.

Painting represents forms and scenes of nature and human life in color, as light, shade and hue, through the aid of form perspective, distance perspective and aërial perspective.

Drama represents scenes in the life of human and mythic heroes by personation or mimicry, combined with literary presentation.

Romance represents biography and history in fictitious tales.

Music represents ideas in sound, by rhythm, melody, harmony and symphony.

Poetry represents psychic pictures by metaphor, through the aid of rhythmic literature, sometimes using rhyme and alliteration.

The arts have thus been described by defining their forms, but each has something more as a reason for its being an æsthetic art—a purpose to fulfil. The motive of all the æsthetic arts is to reach the intellect through symbols, and thus kindle the emotions. All art is therefore symbolic and emotional.

Let us turn to the evolution of music.

This is the burthen of my song, this is the theme that runs through my melody—that music, in harmony with all of the processes of becoming in nature and art, becomes by minute increments—by growth. How, then, did music grow?

It has been assumed by writers that music has its origin and development in the innate appreciation of the human mind for the rhythms, melodies, harmonies and symphonies of nature, that it is the spontaneous outburst of the human soul in response to the music of the physical and animal world. The sighing of the winds, the murmur of the rills, the roaring of the cataracts, the dash of the waves on the shore, the singing of the forests, the melodies of birds, all these and many more have been considered as the teachers of music to man. The objective study of music among the lower tribes of mankind and among the various peoples of the world in different stages of culture, and of the history of music itself as developed by our own race, leads to a different conclusion.

Kids gambol among the rocks as if filled with joy, colts run about the pastures as if mad with ecstasy, cooing babes pommel vacuity and kick at void with hands and feet as pink and soft as petals of the rose, and seem delighted with the gift of newborn life; lads and lasses play in the park with shouts and laughter, as if existence was forever a May-day of sport.

There is pleasure in activity. The laboratory of life evolves a surplus of motion the expenditure of which gives rise to joyous emotions expressed in rollicking, boisterous play.

In youth and health and vigor, there is in the exercise of the muscles and the motions of the limbs a joy which may be heightened as many become associated in the same activities—brothers, sisters, cousins, sweethearts, wives, husbands, and parents. Let them unite in sportive activities and the very ecstasy of motion is produced. When such physical activities are systemized, the dance is organized. When a group of pleasure-seekers organize their activities

in such a manner that the motion of every one is in harmony with the motion of every other one, the merry dance is an art and a social institution, and every one's joy is multiplied by every other one's joy. Then rhythm of motion becomes rhythm of emotion.

Man early learned that it was easier to control movements of dance by sound than by sight, and so he marked the rhythm of the dance by sounds of the voice or by sounds of the drum.

Blue-eyed children play with the brown-eyed, and brown-eyed children play with the black-eyed, and they all join hands and play "ring-around-a-rosy;" and out of this childish sport, by minute increments, musical rhythm becomes.

The first dancers were the men who lived in the forests, around the sheltered bays of the sea, on shores where quiet lakes mirrored the wild bird's flight, or on banks where the fishes sported in the wavelets of the brook.

The Eden of these sylvan men was large. It was walled with ice, so that men could not wander away to the north pole or to the south pole, but between these frozen regions the temperate and torrid lands were open. Before they learned to fashion stone knives, before they learned to use stone tomahawks, before they learned to use bone awls, before they learned to wear shell beads, before they learned to build shelters of boughs and bark and stone—while yet naked animals, men were found in every quarter of the globe. There were men on every shore, and there were men on the banks of every river. Sylvan men and women, boys and girls of the forest, dusky babes of the wood, were scattered throughout the whole habitable earth before the rudest human arts were invented, probably before organized languages were formed, and probably before institutions were organized. How do we know this is true? Is it the story of a romancer who finds the origin of the glacial drift in the lashing of a comet's tail? No, this conclusion is reached through the labors of an army of patient, earnest, keen-visioned investigators. They have found the birth-place of Art not alone in one land, but in all lands. The vestiges of the crudest arts are found everywhere and men began the career of artisans everywhere. It is found that men were already distributed throughout the world when they first began to use the simplest tools. Something more of interest is found. It is discovered that the time when the first art culture began was long ago—very long ago; not long when compared with the geologic history of the earth, but very long when

compared with the book-recorded history of man. Archæologists have found vestiges of the beginnings of human art in geologic formations, and they have found them in all lands. So the "Garden of Eden" was all the world, and the sons of Adam were a host.

As time passed on from that ancient epoch when men had landed on every shore, they slowly, very slowly, improved in their arts. For later and still later geologic formations contain vestiges of higher and still higher arts, until at last men could make pottery and weave garments and cultivate the soil, and from that time on we have human industry recorded in books.

Early human history is recorded in the rocked-leaved bible of geology; late human history is recorded in paper-leaved books of libraries. Let us take up the story of music as a human art at the time when the late history commences, for that will serve our purposes.

All the sylvan people of the world rejoice in dancing. So far as we know, it was the earliest of the æsthetic arts, for we find it highly developed at the very birth of all other fine arts. This is because its foundation is laid in the physical constitution of man; it is the expression of the joy of animal life. These sylvan men danced by firelight, and forever they varied the rhythm of their dances with short steps and long steps, with steps to the right and steps to the left, with steps forward and steps backward; so dances come to be composed of a succession of varied steps, so rounded as to make a complete number in a figure of motion. A figure of motion, a complement of steps, is repeated over and over again and the voices of the dancers are trained to chant the rhythm to guide their feet in the dance. To mark the varied steps to each complement or theme of motion, the voice is varied; long notes and short notes are used, and then loud notes and soft notes; and yet there is nothing but rhythm. Then they begin to vary their voices as a guide to the moving feet by changing the vocal pitch, and the simple chant becomes. First, the voice varies only in time; then it varies in time and stress; then it varies in time and stress and pitch, and the chant is almost a melody. So the music of the lowliest men known to modern investigators is but rhythm. It is the universal music. All music in all times is based on rhythm, but some music has more than rhythm. The music of the savage has been improved. The sylvan man developed the first element of music to a high degree.

At this stage the chant of unmeaning syllables undergoes change, for the emotions that are kindled by the dance are expressed in words — first, a few simple expressions of emotion — mere interjections — then exclamatory phrases, then exclamatory sentences, and the egg of poetry is laid.

This embryonic poetry is devoid of rhythm, for the rhythm yet belongs to the voice, not to the literature. The rhythm does not grow out of the words of the chant, but the rhythm of the chant is imposed on the words.

The stage of culture of this sylvan man is called *savagery;* and it is very long; and during all these centuries, and centuries of centuries, tribes of kindred men dance and chant. At the foot of the glaciers they have their homes, and walls of ice echo their chants; by mountain crags they have their homes, and the rocks echo their chants; in the valleys they have their homes, and the savannas are filled with their chants; in tropical forests they have their homes, and " the sounding aisles of the dim woods " ring with their chants.

When sentences are used to express emotions kindled by the dance, the leader repeats the words and the people chant the refrain, and more and more he gains a freedom in composition, and he varies his chant with new sentences, iterating and reiterating the emotional theme. In this way poetry becomes, and we have dancing-master poets and dance songs. As the dancing-master poet varies his theme of poetry so he varies his theme of music, and melody becomes. Poetry and melody are twins born of the dancing chant. Thus it is that "ring-around-a-rosy" becomes a song.

At first musical rhythm is an auxiliary of the dance — the rhythm of music and the rhythm of motion are partners. When unmeaning syllables are replaced by emotional words and sentences, music and poetry live together. Sometimes it is dancing and music only; sometimes it is dancing, music, and poetry altogether; sometimes it is music and poetry only.

So the grandchild of the dance and the child of the chant grows, and is emancipated from the control of dancing and becomes an art associated with poetry. Priests sing as they perform religious rites, women sing as they grind at the mill, children sing at their sports; and song, as rhythm and melody, exists during all the period denominated *barbarism.*

When freedom comes to song it starts on a new career. No

longer chained to Terpsichorean feet, it soars into the realm of ideal emotion. The dance expresses the joy of exuberant life; the song expresses the joy of exuberant emotion. The dance carries the body through the merry maze; the song carries the soul on its way through the universe of thought.

If I would share my measure of joy with another, behold my measure is still full, and more than full — it overflows. When song comes, men find that though the solo is beautiful, the chorus is more beautiful, and rapidly choral music is developed. At the time to which we refer there is no harmony, but only rhythm and melody. Yet the egg of harmony is laid, for in melody sounds follow one another rapidly, and ere one note leaves the ear another joins it. The waning sound mingles with the waxing sound as the embryo of harmony. Thus melody trains the ear to the appreciation of harmony.

There is still another element of harmony in choral melody. The voices of a varied concourse of people are diverse in pitch. The notes of man are low and resonant like the voices of waves and winds; the notes of women are high and clear like the voices of birds; while children pipe like bees. In folk singing, groups of such voices unite and the elements of harmony are developed. The village life of barbarism when the people form a body of kin and kith promotes this rudimentary harmony, for they meet as one great family and join in many a festival that must ever lead to music and dancing.

And here another art assists in the development of music. The drama begins in savagery. The savage deifies the beast. To him the animals of the world are wonderful.

The eagle lives a life with which he cannot vie. It plays among the clouds, rests on the mountain tops, and soars down to circle over the waves of the sea. The humming bird poises over its blossom cup of nectar like a winged spirit of the rainbow. The deer bounds away through the forest and leaves the hunter lost in amazement. The squirrel climbs the tree and plays about among its branches, and springs from limb to limb and tree to tree, and laughs at the sport. The rattlesnake glides without feet over the rocks, and in his mouth the spirit of death is concealed. The trout lives in the water and flies up the brook as the hawk flies up the mountain. Dolphins play on the waves as children play on the grass. The spider spins a gossamer web; the grub is transformed

into a winged beauty; the bee lays away stores of honey; the butterfly sports in the sunshine like a flower unchained from its stem. The air, the earth, and the waters are peopled with marvellous beings.

The folk-lore of the savage is a vast body of oral literature in which these wonderful animals are the principal actors, and his book of creation is the history of the animal gods. The stories of these animal gods are dramatized, and the priest-doctors of savagery are the actors who play before the people, assuming the parts of beast-gods. For this purpose they dress themselves in the skins of beasts, or wear masks that represent the forms and attributes of their deities. In recitations and dialogues, with much acting and mimicry, they represent the scenes of their mythology to the people. When poetry is born they re-cast their stories in poetic form, and chant and sing their verses.

Drama plays a great part in savage and barbaric life. In the tales of the drama the philosophy of the people is embodied. It contains their history of creation. The human mind is ever interested in the origin of things. The desire to know is the fundamental impulse of the intellect. The wisest and best of all peoples, even among the tribes of sylvan men, devote their highest intellectual powers to the enigmas of creation; and as opinions are formed, they seek to teach them to others. Thus it is in savagery and barbarism that philosophy is embodied in drama and taught to the people. In primitive society the drama is the school of religion, for there its precepts are taught, and its lessons are reflected in the theatrical mirror of life. The drama is deeply embedded in early culture, and is intimately associated with the intellectual growth of the race.

When the drama borrows aid from music, music itself is greatly invigorated. With the new impulse it rapidly develops, and this is the manner of its growth:

When the chorus is sung by skilled performers, the unskilled join in parts, adding a kind of refrain to the music, not by following the undulations of the melody in unison with the principal singers of the chorus, but by chanting on a note in harmony therewith; and thus harmony becomes.

To suit the conditions of the actors in the drama, harmonious parts are developed until one, two, or more accessory chants are produced; then these harmonious parts are developed from acces-

sory chants to accessory melodies, more simple than the principal melody, which still retains the name.

In the music thus developed by our race there are usually four parts—soprano, contralto, tenore, and basso, and these are adjusted to four classes of voices.

Rhythm grows into melody and melody grows into harmony; yet music is young and music must grow, for it blossoms with the promise of becoming divine. Music is to become symphony. Harmony is a combination of coëxistent melodies; but symphony, in its broadest sense, is a combination of sequent harmonies. At the song stage of music, men begin to recite stories, simple dramas, and intersperse their narratives with stanzas of song; then the narratives are chanted, and songs and chants are combined, chants and songs alternating. At this stage a body of sacred music is developed. From hymns grow anthems, and bible passages are rendered in the solemnity of the chant and the majesty of the hymn, for chants and hymns alternate; and anthems by minute increments become oratorios, where bible history is taught in a succession of chants and hymns, changing along the course of the oratorio to express the varied emotions kindled by the sacred story. The mythic drama of the pagan world is represented by the oratorio of the Christian world.

The profane dramas that are recited and sung come to be chanted and sung with instrumental accompaniments. And then are produced the cantatas, or poetic stories set to music; and fugues, or musical dialogues, are composed; and nocturnes, serenade music laden with tender love. Then the cantata is developed into the opera as the drama is wholly set to music and the parts presented by *dramatis personæ*.

Men must laugh sometimes, for tragedy must be set in comedy, as precious stones are ofttimes set in filagree, and so the madrigal is developed, which is an elaborate musical composition of many parts designed for the expression of tender and hilarious joy in alternating movements; it is the comedy of music. And then comes the sonata, designed for solo instruments—a musical composition usually of three or more successive parts, each of which has a unity of its own, yet all so related as to form one varied and consistent whole. From the sonata, music passes to the symphony, which is a musical composition of successive parts having slightly varied but intimately related movements, treated in such a manner,

by varying the time and stress and pitch, as to produce the greatest contrasts. With the anthem and oratorio, the cantata and the opera, the fugue and the madrigal, the sonata and the symphony, music has reached its highest stage in civilization.

The theme is the evolution of music, not the evolution of musical instruments, but something must be said of instruments, for they play an important part in the evolution of music itself. Were I to enter upon this theme fully, the task would be great. Then I should have to tell of thumpers of many kinds, by which the rhythm of the dance is controlled; I should have to tell of rattles by which the dance is enlivened; and I should have to tell of whistles, by which the dance is made merry with screams. Then I should have to tell how thumpers became drums, and how rattles became tambourines, and whistles became flutes; and I should have to tell how twanged flexible strings became violins, and how twanged rigid strings became pianos, and how bark whistles became horns, and how pipes became organs.

The invention of musical instruments begins with the sylvan man, who uses them to mark the rhythm of the dance. Throughout savagery and barbarism only time-marking instruments are invented. Not till civilization came to the people of the shores of the Mediterranean were instruments of melody produced; but when they appeared a new world of music burst upon the delighted ears of civilized man. Beaten instruments, reed instruments, wind instruments and stringed instruments give power and variety, and the capacity for musical production is marvellously increased. Men can sing solos, sing in chorus and sing in parts within the compass of the human voice; but with instruments they can play in unison with like instruments and in harmony with unlike instruments and with a compass far exceeding that of the voice. Then music is enriched by increasing the compass, it is enriched by increasing the volume, but more than all it is enriched by increasing the variety of its kinds. At this stage music is sweet, music is grand — but music must become sublime.

Instruments of music are but instruments of melody until science comes, when it is learned that sound is a mode of motion, and that low sounds are slow vibrations and high sounds quick vibrations. Then the knowledge comes by which man invents instruments of harmony, coëxistent harmony and sequent harmony.

Thus science is the last great agency in the evolution of music, for it produces instruments by which symphonies become possible and music has reached the sublime.

As the blue egg becomes a robin, as the seed becomes a sequoyah, as the sands of the rill become an island, so "ring-around-a-rosy" becomes a symphony.

Feelings primarily arise from biotic pains and pleasures. It is one of the wonderful transformations of nature that the pain of a blow should slowly, through the years of human culture, develop into the sorrow for sin; that the pleasure of a feast should evolve by the metamorphosis of minute changes into the love of justice. How feelings develop into emotions and emotions into sentiments and sentiments into æsthetics is a long and beautiful story which cannot here be told. But the world is full of transformations. The metamorphoses of evolution have been the mysteries of time. In the solution of these mysteries men have been engaged through untold years — peering through their purblind primitive ignorance for more light, reasoning with guesses, philosophizing with myths and believing in errors, but gaining a little truth here and a little there until by minute increments science has been developed. The evolution of science is itself the mystery of mysteries, the metamorphosis of metamorphoses, for the germ of science is mythology.

With the development of intellect, the emotional nature of man by which he loves and hates has been evolved and the æsthetic pleasures have arisen under the law of mental association. By association with the joys of life music has been endowed with its power of producing emotion. This association must be explained.

I have spoken of the growth of music as a combination of sounds in succession and in harmony, as it is made by the human voice, and have alluded to the origin of the instruments by which parlor, orchestral and temple music is produced, but nothing has been said of the means by which music is endowed with its power to produce emotion. I have told of the body of music, but have said nothing of its soul. Music is freighted with joy and sadness, with hope and fear, with courage and cowardice, with glory and shame — it is freighted with all emotion; and how does the form of sound become informed with feeling?

When primitive man — poor, naked, houseless, savage man — lived in the Eden walled by ice and was scattered throughout the

garden of the world, his capacities for pleasure were yet little developed. Still, he joyed much in his rude way. When the wind blew cold he warmed himself by the camp fire, and when the night was dark he illumined his home with fire-light, and about the fire he danced, and in the dance he had resource of joy. When the fisherman came home laden with a bounteous catch, he made merry by the fire-light dance; when the hunter brought in many pheasants or many antelopes, then, with kith and kin, he made merry by the fire-light dance; when the rich nuts fell from the trees in bounty he made merry by the fire-light dance; when the wind blew chill he drove the cold away by the camp-fire dance, and when the night was about him he rejoiced in dancing. So the nights of that region where the stars of the Great Bear are overhead, and the nights of that region where the stars of Orion are overhead, and the nights of that region where the Southern Cross is overhead, in all the habitable lands of the round earth — the nights were spent in dancing and the rhythm of the dance and chant became the language of these rude savage emotions.

But disease and wounds and pain and death were the heritage of this early man. Whence these evils came he knew not; why they came he could not tell. How they were to be driven away was the enigma of all savage thought. Through an illogical philosophy, the origin of which is a long and strange story, he came to believe that diseases were living beings; that toothache is the pain wrought by the gnawing mythic worms; that the cough is caused by mythic insects; that headache is caused by invisible mythic ants; and that all diseases and all pains are produced by these mythic agencies. And he tried to drive them away by shrill shrieks, by mad howling and by horrid imprecation. Then he sought to gain the aid of the friendly spirits of the world — the good mythic beings. To him the rhythm of the dance and the chant was the language of joy; so he sought to woo these friendly spirits by using this language of joy, and when wearied with his own efforts at driving away the maleficent spirits, he turned to the dance and the chant, and with them called for the beneficent spirits. In this manner the sylvan man came gradually to believe in the direct efficacy of dance and music as a medicinal agency. Dance and music are the quinine and calomel of the savage — the "water cure," the "faith cure," the "blue glass cure," the "mind cure," the "Christian science cure," the "youth-restoring elixir," the panacea for all human ills.

When the poor diseased people recovered, the joy of recovery became associated with music. The welcome to health and companionship which the poor invalid received was given in dance and music.

Sometimes storms came and destroyed their rude houses; sometimes drought came and destroyed their harvests; sometimes fierce winds came and congealed their life-fluids; sometimes mad lightning came, and, shivering the trees, ended their lives. And so by flood and wind and lightning and many other agencies, they believed themselves to be persecuted by the spirits of the animal gods who must be appeased; and what would please the god so much as music and dancing? And so they danced to their gods and beat their drums to their gods and played their whistles to their gods and blew their horns to their gods, until the winds stilled and the storms abated and the lightnings went out and the thunders hushed and the floods ran away to the sea, and then they rejoiced with feasting and dancing and music.

Before the sylvan man had learned to plant fields and build storehouses and provide for future days, he believed that every thing was the gift of his animal gods. The earliest provision that mankind made for the future was to lay up a store of their good will. And how could he gain their good will but by dancing and music? So at new moons and at new seasons he held festivals in honor of his gods and gave them dancing and music.

When in a later culture man gathered the fruits of the forest and mead as a store for the winter day and planted fields and gathered grains, he made thanksgiving to his gods in dancing and music.

The rallying cry to war was dancing and music. There is an instrument used by savages in many lands that consists of a simple tablet of wood, a hand's breadth in length and a finger's breadth in width, to which a short string is attached by one end while the other is fixed to a stick like a cane. The performer holding the stick in his hand, whips the tablet of wood through the air in such a manner that it makes a sound, sometimes quick but low, like the whiz of a bullet on the battle-field, sometimes shrill and loud, like the shriek of a cannon-ball thrown into a bombarded city. With these instruments a group of naked savage warriors, intent on plunder, rapine and the midnight murder of men, women and children, gather about the camp-fire in the weird dance, and leap and howl and whip their bull-roarers until they work themselves into a state of fury.

It was in this manner that the music was freighted with emotion by the sylvan man when it was only rhythm, and when it was chained to the dance.

Some music expressed in rhythm and melody has had a long life among all the barbaric and civilized peoples of the world. Minstrels have carried it about; men have sung their songs in field and forest; women have sung their songs at the oven and the loom; boys have sung their songs while driving the herds to pasture, and girls while milking cows; and there are songs for all times and all conditions and all peoples. Song has ever remained as folk-music, the delight of the people.

There are songs celebrating all passions — all joys and all sorrows, all hopes and all fears, all loves and all hates. All the emotions of the human soul are coined into song. Song is the reservoir into which all human feelings are poured, and it is the fountain from which all human feelings may be drawn. And this is true not only in our language, but in all languages.

When harmony was given to music through its association with the drama, musical compositions were no longer confined to simple songs for the field, the fireside, and the chapel, but great pieces were composed for the temple and theatre, and music was made to express the emotions of religion and romance, as in the oratorio, cantata and opera. This music bore on its wings the hope of heaven and the fear of hell. It told of the joy of the angels before the throne of God, and of the torments of demons in the presence of the Devil. The profane music of this period related biographies and histories filled with love and revenge, virtue and crime, courage and cowardice, repose and tragedy. Music in this stage is freighted with the feelings that are kindled and expressed by laughter and crying, by prattle and wrangling, by caresses and blows, by kisses and frowns, by praise and reproof, by plenty and poverty, by strength and weakness, by health and disease, by birth and death, by festivals and funerals, by carnivals and battles, by peace and war, by victory and defeat, by justice and injustice.

And now we must speak of the symphonic stage of music, when science has given it a multitude of sweet instruments.

The art of music was not born of the music of Nature; it was born of the pains and pleasures, the joys and sorrows of mankind.

The appreciation of the beauties of nature is of slow growth, and

it is only in civilization, and with the most cultured people of civilization, that these beauties are sources of joy, and it is only in the latest music that the highest intellectual pleasures are expressed. The beauties of the earth, the sea and the air, and the sublime spectacle of the heavens are gradually being wrought into the emotional nature of mankind, and the new music is informed with the strains that are played by Old Ocean against the shores of every land. It is filled with the anthem-music of the forest and the songs of the birds that chorus the round earth with the rising sun.

In its late history new attributes have been added from the contemplation of nature. These are feelings kindled by the higher intellectual activities. The human reason has acquired a knowledge of the universe and derived exalted emotions therefrom. The boundless sea now tells its story. From arctic and antarctic lands navies of icebergs forever sail, to be defeated and overwhelmed by the hot winds of the tropics. The lands with happy valleys and majestic mountains rise from the sea, built by the waves and fashioned by fire and storm. Over all rests the ambient air, moving gently in breezes, rushing madly in winds, and hurling its storms against the hills and mountains of the sea and the hills and mountains of the land.

The land, the sea and the air are the home of a world of life, which man studies with ever-increasing interest and pleasure. The solid earth is composed of crystalline forms and exhibits chemical activities which ever challenge admiration. Sound and heat and light and electricity and vitality and mentality present modes of motion the contemplation of which fills the mind with delight. Looking above the earth the worlds of the universe are presented to view, and their wonders fill the soul. So music has come to be the language of the emotions kindled by the glories of the universe.

Thus is seen the growth of music in four stages: music as rhythm, music as melody, music as harmony, and music as symphony. Rhythm was born of the dance, melody was born of poetry, harmony was born of drama, symphony was born of science. The motive of rhythmic music was biotic exaltation; the motive of melody was social exaltation; the motive of harmony was religious exaltation; the motive of symphony is æsthetic exaltation. It is thus seen that music develops from the emotional nature of man,

as philosophy has its spring in the intellectual nature. The earliest emotions arose from the biotic constitution,— simple pleasure or pain, as felt in the body and expressed in rhythm; they were mere feelings. Then feelings were idealized and became emotions and were expressed in melody; then the emotions were idealized and became sentiments and were expressed in harmony; then the sentiments were idealized and became intellectual conceptions of the beautiful, the true and the good, and these were expressed in symphony.

Is there a new music for the future? The science of music answers "Yes." We know that music has been chained to "form" and imprisoned in the Bastile of musical intervals and guarded by the henchmen of mathematical dogmas. But a few great musical composers, like Wagner, have broken the chains and burst the bars and killed the jailers, and they sing their liberty in strains of transcendent music.

When it is desired to cultivate skill in musical performance, it is necessary to cultivate the art in the individual in the same order in which it is cultivated in the race; and he must first master rhythm, then melody, then harmony, then symphony. Then the love for music must be acquired in the same order. No one can love a symphony or an opera who does not first love song. If you would love the higher music, you must love the songs of the people; and to affirm that you love a symphony or an opera or a cantata, but that you do not love a song, is like averring that you love a garden but do not love a rose, that you love a bouquet, but care not for a lily; for a symphony is indeed but a bouquet of melodies, and an opera is a garden of many flowers.

Happy is the home that is filled with song, where boys and girls sing the melodies of the people, and where they make these melodies more musical with the violin, the piano or the flute; for to music is consigned the purest joy.

REPORTS OF COMMITTEES.

Report of the Committee on Indexing Chemical Literature.

The Committee on Indexing Chemical Literature respectfully presents to the Chemical Section its seventh annual report.

During the year just closed three bibliographies have been published by the Smithsonian Institution.

A Table of Specific Gravity for Solids and Liquids. The Constants of Nature, Part I (new edition, revised and enlarged). By Frank Wigglesworth Clarke. Washington, D. C., 1888. Smithsonian Miscellaneous Collections No. 659. 8vo, pp. xi, 409.

This volume contains the specific gravities of 5,227 distinct substances and 14,465 separate determinations, being more than twice as many as in the first edition with supplement.

Index to the Literature of Columbium, 1801–1887. By Frank W. Traphagen. Smithsonian Miscellaneous Collections No. 663. Washington, 1888. 8vo, pp. [iv], 27.

This Index contains the threefold arrangement chronological, alphabetical by authors, and subject-matter. The abbreviations of Journal-titles are those adopted by the Committee on Indexing Chemical Literature upon whose recommendation this Index was printed.

A Bibliography of Chemistry for the year 1887 by H. Carrington Bolton. Washington, 1888. Smithsonian Miscellaneous Collections No. 665. 8vo, p. 13.

Prof. Wm. L. Dudley, Vice President of the Chemical Section of the A. A. A. S., has appended to his address on the Nature of Amalgams an Index to the Literature of the subject which will be printed in the forthcoming volume of the Proceedings of the Toronto meeting.

We record the publication of the following index. Lists of patents relating to Soap and Candles in "Manufacture of Soap and Candles" by Wm. Brannt, Philadelphia, 1889.

Also:—An Index of Researches upon the Production of Ammonia from Atmospheric Nitrogen. By Ezra J. Ware. Published in Proceedings Michigan State Pharmaceutical Association, 1888, H. J. Brown, Ann Arbor, Mich., Secretary.

Reports of progress from several volunteer indexers have been

received. Dr. Alfred Tuckerman has completed his Index to the Literature of Thermodynamics except a subject-index to which he is putting finishing touches. He has also begun an Index to the Literature of the Chemical Action of Light, a subject suggested by the Chairman of your Committee.

The publication of this annual report is always followed by numerous applications for information, especially with respect to the method of indexing adopted by the Committee. These inquiries we may in some degree anticipate by repeating the statement that this Committee does not prescribe any standard, nor dictate any system for volunteers to follow. Those interested in the work of the Committee would do well to examine the six reports already published, in which will be found suggestions for systematic indexing (1885), a complete list of indexes already printed under the auspices of the Committee (1887), and a list of "Abbreviations of Titles of Chemical Journals," intended to secure uniformity in references (1887).

The choice of subjects for indexing has generally been made by the volunteers themselves; in a few instances only the topics have been suggested by the committee, at the request of co-workers. These subjects, as shown in our reports, cover a wide range in physical, inorganic and organic chemistry; the desirability of procuring indexes to individual elementary substances should not be overlooked by those who contemplate offering aid. A few copies of the Report of 1887 (which includes lists as above) remain, and can be had on application to the chairman, to whom also letters of inquiry may be addressed care of Smithsonian Institution, Washington.

H. Carrington Bolton, *Chairman*,
F. W. Clarke,
A. R. Leeds (in Europe),
A. A. Julien,
John W. Langley,
Albert B. Prescott,
Chas. K. Wead.

Report of the Committee on the International Congress of Geologists.

Since the last meeting of the A. A. A. S. the London Congress has been held, at which a fair representation of American geologists was present. The reports of the American Committee having been approved by the unanimous vote of Section E at the New York meeting of the A. A. A. S. were, with a few additions (not obtainable for that meeting but unanimously approved by the committee) presented to the Congress and distributed among its members.

Mr. Topley, the General Secretary, ordered a large edition of the American volume, with pagination altered to suit the needs of the volume of the Congress which he was editing.

It has been decided to issue the geological map of Europe in instalments of one or more of the sheets at a time, instead of waiting until the whole map is complete, and this has rendered it necessary to make special arrangements for the delivery of these sheets to the American subscribers who now number the one hundred required to make up the sum paid by the "large countries." Unfortunately the undersigned has not received any response to the letters addressed to Mr. Hanchecorne of the Executive Committee on the map, and is therefore unable to propose a plan of distribution.

The London Congress decided that the next session should be held in Philadelphia, Pennsylvania, United States, and appointed a provisional committee to take such action as might appear best to provide for the session. This committee appointed a larger committee, of which Dr. Newberry is chairman.

Your committee reports progress and asks to be continued.

James Hall, *Chairman*,
Persifor Frazer, *Secretary*.

Report of the Committee on Anatomical Nomenclature, with special reference to the Brain.

During the past year, some of the members of the Committee have given to the subject intrusted to them as much time as their regular duties would permit. They agree upon one point, viz., the advantages, other things being equal, of *mononyms* (single word terms) over polyonyms (terms consisting of two or more words). Before making specific recommendations or presenting a final report, the Committee think it advisable that they and other anatomists should have an opportunity of discussing at leisure the simplified nomenclature which they are informed is employed in certain treatises which will be published during the coming winter. They therefore ask to be continued.

Burt G. Wilder, *Chairman*,
Harrison Allen,
Frank Baker,
Henry F. Osborn,
T. B. Stowell.

Report of the Committee of Section C, on Methods of Analyses of Waters and Statement of Results.

Your Committee offer the following report:

1. That in the course of the year 1887–8 a scheme for stating the results of the analyses of waters, both the so-called mineral waters, and waters used for drinking, was widely distributed to all chemists in this country supposed to be specially interested in the subject, with request for comments, suggestions or reasons for disapproval. This scheme was also printed in the Journal of Analytical Chemistry, and came thus to be still more widely brought to the notice of chemists.

Not half a dozen replies to the circular were received, and chemists most widely known as water analysts were conspicuously wanting, even in this small number.

So far as noticed, the scheme received but little favor, and especially that part of it referring to mineral waters; less objection was taken to the other part, for potable waters, and a uniform method of stating results in parts per million appeared to be more generally acceptable.

In view of the want of interest in this matter on the part of chemists, and especially of those most interested in water analysis, your committee has hesitated somewhat to present any recommendation in regard to it but, nevertheless, offers the following for your consideration.

That in the case of the usual examination of a potable water for sanitary purposes, *all results be stated in parts per million.*

2. That beside giving parts of ammonia, free and albuminoid, and nitrous and nitric acids, there be given also parts of nitrogen as ammonia, free and albuminoid, and as nitrous and as nitric acid: the latter alternative being taken with a view to the ultimate use of this method alone.

With regard to mineral waters your committee has no recommendation to offer.

At the preceding meeting of this Section, your committee was directed to take into consideration also the unification of details of the method of the sanitary examination of water, especially as to the determination of the organic matter, and the nitrogen compounds.

In April of this year a series of questions was sent to the prominent water analysts in the country, or such as were known by the various members of the committee to be so interested, for the purpose of eliciting information as to the methods pursued by them; it being the opinion of your committee that, whatever the course of examination to be recommended for general use, it will be the more likely to meet with the desired adoption, the more it is in accord with the methods followed by those who have had most experience in this work. By the kindness of the editor of the Journal of Analytical Chemistry, a copy of these questions was sent to every subscriber of that Journal in advance of their appearance in the Journal itself.

These questions, together with the introductory explanations, were as follows:

Dear Sir:

At the last meeting of the American Association for the Advancement of Science the Committee of Section C, on methods of stating the results of water analysis, was continued, and it was directed, further, to ascertain and report what can be accomplished towards securing on the part of water analysts uniformity in the methods of examining water used for drinking, and especially as to the organic matter.

It was the decided opinion of the meeting at which this action was taken, that a very great advantage would be gained, in respect to the sanitary study of waters, if at least a certain part of the chemical examination should be conducted on a common plan.

In consideration of the great and increasing importance of this sanitary question, and the more and more prominent position that the chemist is coming to occupy in the consideration of the question, and of the very evident fact that these methods of examination for organic matter, etc., are often not based on sharp and well defined reactions, making it altogether likely, if indeed not almost inevitable that different results should be obtained with different management of the details of the operations concerned; considering also the evident desirability that the confidence of the public in the judgment of the chemists should not be weakened by differences among the chemists themselves, we trust that you will be disposed to join in this movement by coöperating with this committee, and to give such time to the matter now as may be necessary for the answering of the accompanying questions, so far as your own practice leads you to take a practical interest in the subject.

THE COMBUSTION METHOD.

1. Do you use the Frankland combustion process, and if so, does your experience lead you to believe that its general adoption would lead to more useful and concordant results than are obtained by other methods in common use?

THE WANKLYN METHOD.

2. Assuming that you use this method, do you follow it precisely as described in the latest edition of Wanklyn's work on water analysis (1889)?

3. Referring to Mallet's paper in the Annual Report of the U. S. Board of Health, 1882; and assuming it to be allowed that the process as described by Wanklyn may be improved:

Would you not favor the adoption by general consent of the following suggestions made by him on page 208, based as they are on the results of his very extended investigations?

a. "In order to avoid uncertain ending of the collection of ammonia, whether free or albuminoid, stop the distillation when, and not before, the last measure of distillate contains less than a certain proportion—say 1%, — of the whole quantity already collected. This would in many cases involve the necessity of replenishing the contents of the retort with ammonia-free water."

b. "In order to diminish the loss of amines or other volatile forms of nitrogenous matter, a separate distillation should be made with alkaline permanganate added *at once*, in addition to the usual course of treatment prescribed by Wanklyn — distillation begun with Na_2CO_3, and continued after the addition of $KMnO_4$; the results of the two distillations should be compared."

c. "In reporting the results obtained by the albuminoid ammonia process including the determination of free ammonia, the details of the evolution of ammonia, as collected by separate measures of distillate, should always be given."

3. Or in the place of *a* would you favor the adoption of Professor Breneman's proposal (Jour. Am. Chem. Soc., 8, p. 227) to collect a uniform number of portions of 10 cc. each, supposing that you follow the 100 cc. modification, four portions for the free ammonia, and seven for the albuminoid?

4. Would you favor for general adoption the recommendations of Professor Breneman (*loc. cit.*) of a uniform rate of distillation, namely 10 cc. per ten minutes?

5. In the preparation of your permanganate solution do you follow Wanklyn or Mallet, *loc. cit.*, p. 279?

6. Do you follow the 500 or the 100 cc. plan as given by Wanklyn?

7. Will you kindly describe and give reasons for any modifications of the "ammonia" process as described by Wanklyn that you have introduced in your own practice, and that you consider of sufficient importance for general adoption.

OXYGEN CONSUMED.

8. Do you follow Wanklyn, Tidy or Kubel?

9. Assuming that, of course, you would prefer for general adoption the method that you follow: would you kindly give for incorporation in our report a brief statement of the reasons for your preference, and for important objections to the other methods?

10. Please describe and give reasons for any modifications of the process followed, that you have introduced in your own practice, that appear to you to be of sufficient importance for general adoption.

11. Do you regard the estimation of oxidized N. compounds as of sufficient importance for general adoption?

12. If yes, do you estimate them separately or together?

13. Will you please name the methods employed for these estimations, with reference to the place where they are described, and describe such modifications of the methods thus described as you have introduced in your own practice, and which appear to be of sufficient importance to be recommended for general adoption.

BIOLOGICAL EXAMINATION.

14. Do you make any use of biological examination of waters? Does your experience lead you to regard it as practicable and important for general adoption?

To our regret only seven communications were received in reply to this circular, and some of the most prominent water analysts addressed failed to respond. On the other hand, very full and instructive and satisfactory replies were sent to us by a few who have had large experience in this line of work.

The general tenor of these replies is as follows:

1. No one uses the Frankland process.

2. While all follow the principle introduced some years ago by Wanklyn, Chapman and Smith, not one follows the method in detail as now described by Wanklyn in either of the editions of his work. It is Mallet that is followed in this country rather than Wanklyn.

3. Nearly all distil till the ammonia, both free and albuminoid, is completely expelled, or at least go so far as Mallet suggests, the one per cent limit.

b. No one favors this suggestion, although some take account of it indirectly in their modes of operation.

c. Some consider this of great importance, others of none, but the suggestion is favored by a large majority.

4. A uniform rate of distillation, and at about the rate of $\frac{1}{10}$ of

the whole quantity taken in ten minutes is almost unanimously favored.

5. Nearly all follow Mallet.

6. Nearly all take 500 cc.

8. Kubel's method is followed in principle, so far as any determination of oxygen consumed is made. Opinions as to the value of this determination are about equally divided, for and against.

11. Almost universally, yes, and especially by those whose opinions would naturally be regarded as the most weighty.

12. Usually together, unless the qualitative test for nitrites indicates such a large proportion as to seem to make a separate determination advisable.

13. For nitrates and nitrites together, three use the copper-zinc couple, one the acid-phenyl sulphate colorimetric method, and one reduces by aluminum, and estimates the ammonia; the others did not report the methods followed. For nitrites all that report any method, four in number, use the Griess method.

14. Unanimously, no, either because it is believed to be as yet uncertain in its indications, or because they have had no experience with it.

Your committee feel that if this summary represented the practice and opinions of a large number of chemists of reputation, including at least most of the prominent water analysts, and the recommendations that follow were based on such a fairly representative summary, a long step might be taken in the unification of the details of the examination of water with reference to its fitness for domestic use.

But under the circumstances it seems to them wise, while not yet relinquishing the undertaking, to move deliberately, and to recommend a course of procedure for the examination of such waters, only for provisional adoption, which shall be printed and distributed as soon as practicable, trusting that a wider interest may yet be awakened in the matter, and many more communications be sent in for the consideration of a future meeting.

On this understanding the following course of examination of a water, for the estimation of its nitrogen compounds and organic matter, is recommended. It is based essentially on the recommendations of Mallet and Smart, as given in the Report of the National Board of Health for 1882, and is in the main in accord with the best practice in this country, so far as we can learn what that prac-

tice is. Full details of the course are given here only when they are essentially different from those given by Wanklyn in his latest work on water analysis.

The reagents:—The solution of *sodium carbonate* must itself be tested for ammonia, even though made with freshly heated salt and ammonia-free water.

For the solution of *alkaline potassium permanganate*, dissolve the usual quantities of these reagents (8 grams of $KMnO_4$ and 200 grams of KOH) in 1250 cc. of water and then boil down to 1000 cc.

For the *Nessler reagent* follow Mallet-Smart (*loc. cit.*, p. 279).

For the standard solution of *ammonium chloride*, dissolve the salt in ammonia-free water.

The apparatus:— The neck of the retort is to be drawn out so that it will pass for the distance of one or two inches into the condenser, and a tight connection is to be made between the two by means of rubber tubing slipped over them, or by means of a rubber cork. If a flask is used instead of a retort, the connection between the tube from the flask and the condenser is to be made in a similar manner.

The process:—200 (or 40)[1] cc. of distilled water are put into the retort or flask of suitable size, with 10 (or 2) cc. of solution of sodium carbonate, the water is boiled down to about 100 (or 20) cc. and the last portion of 50 (or 10) cc. is nesslerized. If not free from ammonia, more water must be added and the boiling repeated till no appreciable amount of ammonia is contained in the last 50 (or 10) cc. of distillate.

Then 500 (or 100) cc. of the water to be examined are added, and the distillation and nesslerizing are conducted as described by Mallet-Sharp (*loc. cit.*, p. 280), the rate of boiling being so regulated that very nearly 50 (or 10) cc. of distillate will be collected in each succeeding ten minutes.

For the *total* ammonia a second retort or flask is cleaned in the same manner as above described, except that 50 (or 10) cc. of alkaline potassium permanganate are added, instead of the sodium carbonate. Another portion of 500 (or 100) cc. of the water is added, and the distillation and nesslerizing conducted in the manner above indicated.

[1] The figures in parentheses indicate the quantities to be taken in case the 100 cc. modification of the method is followed.

The subtraction of the *free* ammonia of the first operation from the *total* ammonia of the second gives the albuminoid ammonia.

In nesslerizing, five minutes are to be allowed for the full development of the color.

The details of the evolution of ammonia in the several distillates are to be recorded.

Loss of ammonia from imperfect condensation being easily possible, this should be reduced to a minimum by the use of as free a supply of condensing water, and of as low a temperature, as practicable.

All this ammonia work is to be done in a room free from any contamination of the air with ammonia, and if possible in a special room set apart for it.

Oxygen consumed:—Kubel's method as given by Smart (*loc. cit.*, p. 280) is to be followed.

Oxidized nitrogen compounds:—Nitrates and nitrites together are to be determined by the copper-zinc couple. Nitrites are to be determined by the Griess method Tanner (*loc. cit.*, p. 280).

Chemists everywhere are recognizing the importance, in public work, of uniformity in the methods of analysis followed; in no country has more been accomplished in the unification of methods than in our own, particularly under the auspices of the Association of Official Agricultural Chemists. No one can read the history of their work without realizing the necessity that it should have been done, and its value.

Much of that work refers to processes of analyses that would seem much less liable to variation in results in different hands, than would be the case with the processes that we use in sanitary water analysis. One of us being this year in charge of a portion of that work, the analysis of cattle foods, he may be allowed to quote an illustration of this point from the results received, the operation being such a simple one as the determination of the ether-extract. The sample of hay was prepared in large quantity, in a finely ground condition and most carefully mixed, and sent in portions to each of the sixteen experiment station chemists who volunteered to take part in the work: the results, calculated to dry substance, ranged from 2.66 to 7.10. All the analysts were supposed to work by the same method and with precisely similar reagents, for which full directions were given; but their reports

of the details showed that at least in some respects these details were not everywhere alike. This is, to be sure, an extreme case; but if other discrepancies are not so great, there are still far too many of them that are discouragingly large, and for the elimination of which more work must be done before the Association can consider its work on the analysis of cattle foods as finished.

Public analytical work is done by chemists of all degrees of training, skill and experience, and differences in results may be due to this to some extent, how large it is difficult to decide; but it seems reasonable to suppose that these differences will be materially lessened, if the methods of analysis followed are the same in detail, provided, of course, that the methods are as reliable as they can be made. Some of the most important of this analytical work in the sanitary examination of water is confessedly not sharp in respect to the reactions involved, and for this reason uniformity in the management of the details would seem to be so much the more an urgent necessity.

Your committee trust therefore that the course here recommended will so far meet the approval of water analysts, non-members as well as members of this Association, that, for the reasons mentioned above, they will be ready to follow its details, at least on trial as a provisional arrangement, in their own work.

In conclusion, we would refer to the interesting results obtained by Professor Drown in the application of the Kjeldahl method for nitrogen to the sanitary examination of water as seemingly full of promise of sharper results than any that can be obtained by the Wanklyn process, and well worthy of careful comparison with that.[1]

G. C. Caldwell,
J. W. Langley,
J. A. Myers,
W. H. Seaman,
R. B. Warder.

[1] Prof. W. P. Mason, a member of the Committee, is in Europe at the time of presenting this Report, and has had no opportunity to see it.

Report of the Committee of Conference on the Organization of a National Chemical Society.

Your Committee report that they have been in consultation with committees of conference appointed by (1) The Society of Official Agricultural Chemists, (2) The American Chemical Society holding meetings in New York, (3) The Washington Chemical Society, and (4) The Chemical Section of the Franklin Institute. Also they have consulted with a number of the best known chemists in several sections of the country, and have conversed on the subject of the proposed society, with those engaged in chemistry, here and there, as opportunity has permitted.

1. The census of opinion.

The four committees of conference, without dissent declare their conviction that the organization of a society of American chemists is most desirable, and already feasible. The individual chemists, almost without exception, express their belief that the Society proposed, if strong enough for healthful life, would be of much advantage. On the question of the feasibility of the society as an organization of strength and credit the individual chemists consulted have been divided in opinion. Those who doubt the practicability of the organization, or deny it, do so upon the following named grounds: (1) The annual meetings could not have good attendance because distances in this country prevent it. (2) A hearty coöperation of chemists is clogged by local prejudices and by apathy. (3) Efforts for satisfactory organization in the past have met with failure. (4) Societies in this country find a level below that of the best research. (5) A new society would be liable to add a new journal, while there ought rather to be consolidation of existing journals. (6) An independent society as proposed would weaken Section C. Those who affirm the feasibility of a good society of American Chemists set forth reasons as follows: (*a*) Notwithstanding separation of chemists by American distances we have one centre where they come together, and more and more must come, and this is the annual meeting of the American Association for Advancement of Science. (*b*) Neither apathy nor local prejudice can very

long prevent a large body of American specialists from organizing a distinctive union. (*c*) The past is not the pattern of the future in respect to chemistry in this country. (*d*) Societies of scientific work have been found not to weaken true research, but rather to extend its inspiration. (*e*) A healthful society would serve to consolidate periodical literature, and this is to be the specific effort of the Society to be formed. (*f*) With the safeguards to be set by this Association, Section C will gain strength by coördination with the new society. The local sections will serve as feeders, bringing the strength of the specialists, in an independent organization of clear-cut character, into alliance with the American Association in all its breadth and liberality, for mutual advantage.

2. The time for organization.

Upon a full canvass of the situation your committee have been convinced that the time is coming for a society of American chemists. That the time has now come your committee are not prepared to say, but they submit that the time will come whenever the working chemists will heartily unite in the organization.

3. Coördination with the A. A. A. S. is indispensable.

There is but one centre accessible enough and attractive enough for the annual meetings of the new society, and this centre, not always in the United States, is *always the meeting of the American Association*. To organize for further union, chemists must cherish the growing chemical aggregation in Section C, now of permanent standing and great social advantage, and an alliance with this Section, carefully framed for *mutual* benefit, must be fundamental in the new organization.

4. Consolidation of chemical periodicals.

Beside the journals of distinctive credit there is in the United States and the Canadas a wide range of fragmentary chemical literature of periodical issue, often interrupted, yet of permanent value. From the work of the various academies of science, and from the reports of the various bureaus of science in civil service, the agricultural stations and commissions, the boards of health, the government surveys, geological and metallurgical commissions and associations, the patent office, the chemical service of the great corporations, railroads, mines and manufactures,—from all these, every year, a considerable body of original literature in pure and applied chemistry ought to be gleaned and made accessible to the world. Especially is this true of chemical technology. The industrial

chemistry of this country is original, and full of value both to industrial art and to pure science, while as a rule an American chemist can find in literature the technology of every civilized country except his own. It should be the duty of a publication representing a society of American chemists to summarize the noteworthy chemical results of all the American workers. For the most part, abstracts instead of full memoirs should be given. Moreover, it should be the distinct purpose of the new society, so far as possible, to favor consolidation with the established periodicals of distinct credit in this country. Your committee beg leave to recommend a wise and liberal policy, to this end, with all reasonable concessions at the beginning, so that the expenses of the needed journals shall be made as low as possible to subscribers. And it seems to this committee inadvisable to engage in that publication of abstracts of all current chemistry, now done so well and in such vast proportions by European publications which active chemists must keep at hand. With a true policy of public helpfulness, a society of real national proportions in hearty working unity must promote consolidation of periodical literature, as a fragmentary society must hinder the same.

5. A society should not go forward without an assured basis.

A sufficient membership ought to be pledged, upon a provisional plan of organization, in representation of the entire country, before the society should take date as an independent body. Until the membership reaches a sufficient number, to be designated by this Association, let the constitution of the society remain an unfulfilled proposal of Section C.

6. An order of procedure.

Whenever the Chemical Section and the Council may decide that the time has come for provisional organization, it is recommended that the Section do then nominate and the Association appoint a Committee of Organization of a Society of American Chemists: to frame constitution and by-laws, to address chemists, and obtain pledges of membership. The committee to be bound by certain instructions to be framed by this Association. The membership of the committee as nominated by Section C, to include representatives of the Society of Official Agricultural Chemists, the American Chemical Society holding meetings in New York, the Washington Chemical Society, and the Chemical Section of the Franklin Institute; and the committee to have power to add to its membership

from chemists of appointment by local societies, provided that the appointees of this Association remain a majority of the voting members of the committee. And that the American Chemical Society holding meetings in New York be invited to submit its constitution and operative laws for the use of the committee, also to yield its name to the new society, and to go forward as the New York Section of the American Chemical Society, retaining under its corporate control as a section the property and vested rights it now holds.

ALBERT B. PRESCOTT,
ALFRED SPRINGER,
EDWARD HART.

REPORT OF THE COMMITTEE ON CHEMISTRY TEACHING.

THE Committee regret to say that one of their number, Prof. W. A. Noyes, was absent in Europe the entire year and therefore could not give personal attention to this report.

In presenting their report and asking to be discharged from the further consideration of the subject, the Committee beg to say, that so much has been written bearing on the matter committed to them, that they felt it unnecessary to enlarge as much as would have been desirable, if their report was the first of its kind.

They endeavored to give some testimony not found in the other reports and to add the influence of the Chemical Section in favor of the increasing public interest in and attention to science teaching in general and chemistry in particular.

Among the publications alluded to, deserving especial attention in this connection, are:

Circular No. 6 of the Bureau of Education U. S., on Teaching of Chemistry and Physics in the U. S. F. W. Clarke. 1880.

Report on Science in Schools, American Society of Naturalists, 1888.

Report of the National Educational Association, 1887.

Report of the Committee on Physics Teaching to A. A. A. S., 1888.

Report of the Committee of the British Association for the Advancement of Science, on Chemistry Teaching, Bath Meeting, 1888

The science of chemistry is of very recent growth and has but lately received consideration in arranging courses of high-school studies.

The first collegiate chair of chemistry in this country was established at Princeton in 1795. In 1824 the Rensselaer Polytechnic Institute was opened, the first of the technical schools now so numerous, in which chemistry holds an important place. In 1838, Charles T. Jackson, of Boston, opened his laboratory for practical instruction, perhaps the first instance of its kind among us.[1]

As regards the popular estimate of its value as a part of education, statistics show that, while the number of students taking classical courses barely keeps pace with the increase of population, the number selecting scientific courses, in most of which chemistry holds a prominent place, increases more rapidly than the increase of population, and that chemistry and cognate branches are year by year added in larger proportions to the regular college courses.

This progress is perfectly rational. A science which treats of the constitution of matter itself is entitled to particular attention as a part of the foundation of all correct reasoning about the marvellous transformations of matter that form a distinguishing feature of our modern civilization. And since its laws and principles require special training to be understood, it seems particularly needful that every rational scheme of public instruction should give due prominence to this science.

Chemistry and the other natural sciences are as efficient for mental discipline, as valuable for educating the judgment, and as useful a preparation for the practical duties of life, as language or mathematics.

The Committee began their work by formulating the following questions:

1. At what time should the teaching of chemistry begin?
2. How much time should be given chemistry before and in the high school?
3. The best methods of teaching in the grammar school?
4. The best methods of teaching in the high school?

We believe that very young children may be profitably interested in a few simple lessons on the common chemical phenomena of our daily life. In our opinion, public school teachers should be re-

[1] In Scientific American of June 9, 1888, will be found a sketch of the life of Professor Booth of Philadelphia, by Marcus Benjamin, from which it appears that Professor Booth opened his laboratory in 1836 for instructions in chemistry.

quired to have such an elementary knowledge of chemistry as would enable them, even in the primary grades, to impart accurate information regarding the constitution of air, water, foods, etc., and to explain the nature of combustion and other common chemical processes, and that they ought also to be able to perform a few simple and inexpensive experiments.

As the public schools are not intended to give special instruction, but to lay such a foundation of general culture as is best adapted under the given conditions to meet the wants of all classes of the community, every study scheme, in our opinion, should start from a careful decision as to the division of time between the leading branches of learning, considered in classes, for example: language, mathematics, chemistry and physics, biology, understanding by biology all branches relating to living beings, as physiology, botany, zoölogy, etc.

An examination of the schemes of study in actual use in public schools will show greater differences that can possibly be warranted by variety of circumstances, if we leave out of consideration differences of opinion as to the relative value of different kinds of knowledge.

The Bureau of Education has kindly furnished us advance sheets from its forthcoming report, containing the results of the first inquiry of its kind yet undertaken in this country, for the purpose of finding the relative number of students taking particular courses of study in 347 public high schools, attended by 64,584 pupils, and the time assigned to leading branches in seventy-one of these schools.

The first table shows that the percentage of students pursuing different branches of study ranges in the following order.

Mathematics, 85.81.
English Language and Literature, 61.78.
Latin, 35.79.
Physics, 25.19.
German, 14.82.
Chemistry, 12.88.
French, 7.71.
Greek, 3.55.

The preponderance of German over chemistry is due to the large number of students of that language in the north central division of the United States, where so many Germans live.

The reports received from these schools as to the time assigned

to different branches of study differed greatly in character. On account of different interpretations put upon the inquiry and the different conditions existing where the interpretations were the same, it was impossible to embody all the information elicited in a single tabular scheme.

Choice was made of answers relating to courses of four or five years' duration, which are the periods generally comprised in secondary instruction.

In selecting the answers for tabulation, it was necessary also to distinguish between those that pertained to the work of a class as arranged for a continuous course and those that evidently gave the time devoted by all classes to the several studies or the time occupied by the teachers of those studies. The distinction was indicated by the total number of hours making up the school week. The choice was further limited to the reports which included the three lines of study embraced in the inquiry, viz., language, mathematics and physical science.

The reports of seventy-one schools accorded with the basis of choice. They show the following results: S. for scientific, C. for classical.

In the table the first two columns show the number of schools that do not give any instruction in the branches named in the courses as they report them.

The last two columns show the average percentage of time allotted the branches named in those schools in which the given study is a part of the course.

	C.	S.	C.	S.
Latin,	7	32	20.75	14.93
Mathematics,	4	8	20.54	22.85
English literature,	12	10	17.32	20.52
Greek,	36	61	12.70	6.09
German,	34	37	8.87	10.71
French,	39	44	6.66	9.01
Physics,	13	8	5.05	6.07
Other sciences,	—	—	4.77	5.01
Chemistry,	18	15	3.34	4.81

Of the 71 schools, 8 report no classical course, 24 no scientific. Bennington, Vt., reports Latin 50 per cent, other languages 15 per cent, mathematics 14 per cent, physics 1.23 per cent and chemistry 2.07 per cent in what is called a scientific course.

The average time given to chemistry scarcely differs in the classical and scientific courses, on the whole only 1.47 per cent. Chemistry and physics, taken together, about equal the French or the German. In those courses in which Latin is taught, it receives about one-fifth to one-seventh of the entire time, and it is taught in the scientific courses of 38 of the 71 schools, according to the reports.

If it is taken for granted that by "other studies" is meant chiefly biological sciences, as botany, etc., we shall find appropriated, for the concrete studies, about 13 per cent of the school time in the classical and 16 per cent in the scientific.

It is not asserted that these figures are absolutely correct, but they are the best attainable, and very much better than any mere guesses to show the actual condition of public high-school instruction at the present time in this country.

It is evident from the above facts that there is a diversity of arrangement of courses of study in our high schools beyond that required by any sound judgment, that some of the courses called scientific are misnamed, and that chemistry receives the least attention of any class of studies.

We think that this neglect of chemistry, in our public-school instruction, is one of the causes of many popular mistakes and misapprehensions from which the community suffers.

In addition to the statistics given above for the public high schools, we present herewith similar tables for sixty-six private secondary schools, an analysis of which would show results similar to those already given, with a higher per cent of chemistry.

PRIVATE SCHOOLS.

Classical.		*Scientific.*	
Latin,	24.77	Mathematics,	24.85
Mathematics,	22.46	English Literature,	18.10
English Literature,	14.92	Latin,	16.31
Greek,	9.62	German,	10.44
German,	9.26	Other sciences,	8.33
Physics,	5.56	Physics,	7.05
French,	5.40	French,	6.13
Chemistry,	4.13	Chemistry,	5.68
Other sciences,	4.01	Greek,	3.09

The importance of giving due place to science in secondary pro-

grams appears the greater when it is remembered that the larger proportion of their students do not pass on to college or technical school. This fact is made very clear by the analysis of the results of a recent inquiry by the Bureau of Education as to the number of secondary students preparing for colleges or superior schools of science.

The proportion of such students in the several classes of schools was as follows: high schools, 15 per cent; private schools for girls, 10 per cent; private schools for boys, 63 per cent; private schools for both sexes, 10 per cent.

But a part of the public-school scholars reach the high school, so that, if some instruction is not given in the grammar school, many children will remain entirely ignorant of chemistry, and our opinion is that it should not only be taught in the high school, but that it should form a part of the instruction given in the higher grades of the grammar school.

In this recommendation we agree with the American Society of Naturalists in their report on science in the schools of last year.

Various methods of teaching may be practised with success, and as the Committee were unable to agree upon specific recommendations, it was judged proper to add their individual suggestions in the hope they may be found useful to those interested.

Signed by

WM. H. SEAMAN,
H. W. WILEY,
W. O. ATWATER,
W. L. DUDLEY.

One method for the grammar school is to employ a skilled lecturer with portable apparatus, who shall deliver one lecture a week to the grammar schools in turn, well illustrated, that the students may have the opportunity of seeing the usual chemical experiments, and that to these lectures be added two recitations per week to the usual teacher. Grammar-school instruction to be confined to descriptive chemistry.

The course in the high school to be not less than two years, the first part to consist of lectures on the principles of chemistry, with pertinent illustrations as far as possible, and with full amount of blackboard exercises on writing formulæ and equations and some stoichiometrical work.

Where the opportunity can be afforded, the last part of the course should, of course, consist of laboratory exercises.

I think the elective system should not be introduced into the high schools further than to have a classical and a scientific course.

WM. H. SEAMAN.

I believe that science should be taught children from the beginning of their school work. In the primary schools the teaching should be general and not confined to any particular science. The main object being to train the observing, reasoning and descriptive powers of the mind, all the instruction should be given with the objects (or in some cases with good drawings) before the pupil. He should be instructed by judicious questioning, being allowed to do his own observing and reasoning as far as possible. He should be required to prepare written descriptions in the presence of the teacher. I think the work should be wholly conducted without a text-book. This kind of instruction should continue to the high school, when the several sciences may be recognized and taught A course of lectures to high school pupils, with experiments by the teacher, may be better than no chemistry at all, but I believe it is very little better. The chemistry taught in the high and preparatory schools should consist of a systematic course of experiments, logically arranged, so as to lead the pupil to do his own reasoning. The pupil should do his own experimenting and should be taught as recommended for the primary schools.

WM. L. DUDLEY.

I do not believe that special instruction in chemistry should be given. It is impracticable to teach chemistry professionally in a great public school. A short course of lectures, with experiments and possibly simple laboratory work illustrating the general principles of the science, is all that can be reasonably expected.

An elective course which would allow a few pupils to take chemistry as a laboratory and special study is not in harmony with the purpose of a public school.

In general, I would say, for public school pupils, especially in the secondary schools, the fundamental principles of inorganic chemistry and organic, illustrated by a few inexpensive experiments, are sufficient. All studies of chemistry of a professional or elective nature should be left for the elective courses of the college, the technical school and the university.

H. W. WILEY.

I do not think it necessary that chemistry should form a part of every high-school course. It is not advisable to begin the study before the last year or last but one of the course, and the study of chemistry should be preceded by the study of physics.

When chemistry is introduced at all in the high school, there should be given at least two terms, and, if possible, a year's work of, say, two or three hours of lectures and recitations from text-book, and four to six hours of laboratory work in a week.

The best method of teaching is probably recitation from a text-book, accompanied by demonstrative experiments performed by the teacher, and by laboratory work on the part of the student, the latter not to follow rigidly any text-book.

My idea of the best method of laboratory work is to give each student a subject to work upon, and let him study up carefully from larger works and keep him at it until he can give a satisfactory report. In this way the student comes in contact with the teacher as an individual and does not feel that he is being dealt with *en masse*.

Another feature desirable in the most elementary course, as it seems to me, is the introduction of quantitative experiments, measurements of gases and liquids and weighing with reasonably accurate instruments.

W. A. NOYES.

REPORT OF THE COMMITTEE ON SPELLING AND PRONUNCIATION OF CHEMICAL TERMS. [This report will be found at close of Section C papers.]

REPORT OF P. H. DUDLEY, THE HONORARY AGENT OF TRANSPORTATION.

THE Central Traffic Trunk Line and Southern Passenger Association acted in unison in granting a reduced rate and conditions to members attending the Toronto Meeting.

The above Associations are very courteous, and should future meetings have five hundred or more in attendance, I think a rate of one fare for the round trip could be secured.

The Western Passenger Association refused to grant any concession, giving as a reason, that the number of members who would go from their territory would not warrant a reduction. The New England Passenger Association did not grant any concession, owing to the fact that part of their railroads are in the Trunk Line Association.

The Canadian railways granted concessions through the local transportation committee.

There is great confusion in regard to members obtaining certificates for reduced fare. Of course it is intended that the circular of the local committee should give a full explanation; this however can only be very general and many important specific details for some sections of the country are omitted.

A circular should be prepared stating the railroads granting concessions in each Passenger Association, with specific details in

regard to the certificates necessary to obtain the reduced rate from the meeting. Such a circular should go out from the office of the Permanent Secretary, and also be printed in the Proceedings.

This would in no way interfere with the circular of the local committee, but would be of great service to many members, as many inquiries and letters have been received this year upon the subject.

New York, August 27, 1889.

Mr. W. R. Callaway, District Passenger Agent of the Canadian Pacific Railway Company, and chairman of the local committee of transportation for the Toronto Meeting, upon reading the foregoing made the following statements:

"I entirely agree with Mr. Dudley in this matter. I think an immense amount of labor would be saved by having a map plate prepared, showing the divisions of the various passenger and traffic associations.

I enclose you herewith such a map as used by the Central Traffic Association. I think a map of this size could readily be made to show the divisions of all the Traffic Associations."

Toronto, August 31, 1889.

SECTION A.

MATHEMATICS AND ASTRONOMY.

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ADDRESS

BY

ROBERT SIMPSON WOODWARD,

VICE PRESIDENT, SECTION A.

THE MATHEMATICAL THEORIES OF THE EARTH.

THE name of this section, which, by your courtesy, it is my duty to address to-day, implies a community of interest amongst astronomers and mathematicians. This community of interest is not difficult to explain. We can of course imagine a considerable body of astronomical facts quite independent of mathematics. We can also imagine a much larger body of mathematical facts quite independent of and isolated from astronomy. But we never think of astronomy in the large sense without recognizing its dependence on mathematics, and we never think of mathematics as a whole without considering its capital applications in astronomy.

Of all the subjects and objects of common interest to us, the earth will easily rank first. The earth furnishes us with a stable foundation for instrumental work and a fixed line of reference, whereby it is possible to make out the orderly arrangement and procession of our solar system and to gain some inkling of other systems which lie within telescopic range. The earth furnishes us with a most attractive store of real problems; its shape, its size, its mass, its precession and nutation, its internal heat, its earthquakes and volcanoes, and its origin and destiny, are to be classed with the leading questions for astronomical and mathematical research. We must of course recognize the claims of our friends the geologists to that indefinable something called the earth's crust, but, considered in its entirety and in its relations to similar bodies of the universe, the

earth has long been the special province of astronomers and mathematicians. Since the times of Galileo and Kepler and Copernicus it has supplied a perennial stimulus to observation and investigation, and it promises to tax the resources of the ablest observers and analysts for some centuries to come. The mere mention of the names of Newton, Bradley, d'Alembert, Laplace, Fourier, Gauss, and Bessel, calls to mind not only a long list of inventions and discoveries, but the most important parts of mathematical literature. In its dynamical and physical aspects the earth was to them the principal object of research, and the thoroughness and completeness of their contributions toward an explanation of the "system of the world" are still a source of wonder and admiration to all who take the trouble to examine their works.

A detailed discussion of the known properties of the earth, and of the hypotheses concerning the unknown properties, is no fit task for a summer afternoon; the intricacies and delicacies of the subject are suitable only for another season and a special audience. But it has seemed that a somewhat popular review of the state of our mathematical knowledge of the earth might not be without interest to those already familiar with the complex details, and might also help to increase that general interest in science, the promotion of which is one of the most important functions of this association.

As we look back through the light of modern analysis, it seems strange that the successors of Newton, who took up the problem of the shape of the earth, should have divided into hostile camps over the question whether our planet is elongated or flattened at the poles. They agreed in the opinion that the earth is a spheroid, but they debated, investigated, and observed for nearly half a century before deciding that the spheroid is oblate rather than oblong. This was a critical question, and its decision marks perhaps the most important epoch in the history of the figure of the earth. The Newtonian view of the oblate form found its ablest supporters in Huygens, Maupertuis and Clairaut, while the erroneous view was maintained with great vigor by the justly distinguished Cassinian school of astronomers. Unfortunately for the Cassinians, defective measures of a meridional arc in France gave color to the false theory and furnished one of the most conspicuous instances of the deterring effect of an incorrect observation. As you well know, the point was definitely settled by Maupertuis' measurement of the Lapland arc. For this achievement his name has become famous in literature

as well as in science, for his friend Voltaire congratulated him on having "flattened the poles and the Cassinis" and Carlyle has honored him with the title of "Earth-flattener."[1]

Since the settlement of the question of the form, progress towards a knowledge of the size of the earth has been consistent and steady, until now it may be said that there are few objects with which we have to deal whose dimensions are so well known as the dimensions of the earth. But this is a popular statement, and like most such, needs to be explained in order not to be misunderstood. Both the size and shape of the earth are defined by the lengths of its equatorial and polar axes; and, knowing the fact of the oblate spheroidal form, the lengths of the axes may be found within narrow limits from simple measurements conducted on the surface, quite independently of any knowledge of the interior constitution of the earth. It is evident in fact, without recourse to mathematical details, that the length of any arc, as a degree of latitude or longitude, on the earth's surface, must depend on the lengths of those axes. Conversely, it is plain that the measurement of such an arc and the determination of its geographical position, constitute an indirect measurement of the axes. Hence it has happened that scientific as distinguished from practical geodesy has been concerned chiefly with such linear and astronomical measurements, and the zeal with which this work has been pursued is attested by triangulations on every continent. Passing over the earlier determinations as of historical interest only, all of the really trustworthy approximations to the lengths of the axes have been made within the half century just passed. The first to appear of these approximations were the well founded values of Airy,[2] published in 1830. These, however, were almost wholly overshadowed and supplanted eleven years later by the values of Bessel,[3] whose spheroid came to occupy a most conspicuous place in geodesy for more than a quarter of a century. Knowing as we now do that Bessel's values were considerably in error, it seems not a little remarkable that they should have been so long accepted without serious question. One obvious reason is found in the fact that a considerable lapse of time was essential for the accumulation of new data, but two other possible reasons of a

[1]Todhunter, History of the Theories of Attraction and the Figure of the Earth. London, 1873, Vol. I, Art. 195.

[2]Encyclopedia Metropolitana.

[3]Astronomische Nachrichten No. 438, 1841.

different character are worthy of notice because they are interesting and instructive, whether specially applicable to this particular case or not. It seems not improbable that the close agreement of the values of Airy and Bessel, computed independently and by different methods—the greatest discrepancy being about one hundred and fifty feet,—may have been incautiously interpreted as a confirmation of Bessel's dimensions, and hence led to their too ready adoption. It seems also not improbable that the weight of Bessel's great name may have been too closely associated in the minds of his followers with the weights of his observations and results. The sanction of eminent authority, especially if there is added to it the stamp of an official seal, is sometimes a serious obstacle to real progress. We cannot do less than accord to Bessel the first place amongst the astronomers and geodesists of his day, but this is no adequate justification for the exaggerated estimate long entertained of the precision of the elements of his spheroid.

The next step in the approximation was the important one of Clarke[1] in 1866. His new values showed an increase over Bessel's of about half a mile in the equatorial semi-axis and about three-tenths of a mile in the polar semi-axis. Since 1866, General Clarke has kept pace with the accumulating data and given us so many different elements for our spheroid that it is necessary to affix a date to any of his values we may use. The later values, however, differ but slightly from the earlier ones, so that the spheroid of 1866, which has come to be pretty generally adopted, seems likely to enjoy a justly greater celebrity than that of its immediate predecessor. The probable error of the axes of this spheroid is not much greater than the hundred thousandth part,[2] and it is not likely that new data will change their lengths by more than a few hundred feet.

In the present state of science, therefore, it may be said that the first order of approximation to the form and dimensions of the earth has been successfully attained. The question which follows naturally and immediately is, how much further can the approximation be carried? The answer to this question is not yet written, and the indications are not favorable for its speedy announcement. The first approximation, as we have seen, requires no knowledge

[1]Comparisons of Standards of Length, made at the Ordnance Office, Southampton, England, by Capt. A. R. Clarke, R.E. Published by order of the Secretary of State for war, 1866.

[2]Clarke, Col. A. R., Geodesy. Oxford, 1880, p. 319.

of the interior density and arrangement of the earth's mass; it proceeds on the simple assumption that the sea surface is closely spheroidal. The second approximation, if it be more than a mere interpolation formula, requires a knowledge of both the density and arrangement of the constituents of the earth's mass, and especially of that part called the crust. "All astronomy," says Laplace, "rests on the stability of the earth's axis of rotation."[1] In a similar sense we may say all geodesy rests on the direction of the plumb-line. The simple hypothesis of a spheroidal form, assumes that the plumb-line is everywhere coincident with the normal to the spheroid, or that the surface of the spheroid coincides with the level of the sea. But this is not quite correct. The plumb-line, is not in general coincident with the normal, and the actual sea level or geoid must be imagined to be an irregular surface lying partly above and partly below the ideal spheroidal surface. The deviations, it is true, are relatively small, but they are in general much greater than the unavoidable errors of observation and they are the exact numerical expression of our ignorance in this branch of geodesy. It is well known, of course, that deflections of the plumb-line can sometimes be accounted for by visible masses, but on the whole it must be admitted that we possess only the vaguest notions of their cause and a most inadequate knowledge of their distribution and extent.

What is true of plumb-line deflections is about equally true of the deviations of the intensity of gravity from what may be called the spheroidal type. Given a closely spheroidal form of the sea-level and it follows from the law of gravitation, as a first approximation, without any knowledge of the distribution of the earth's mass, that the increase of gravity varies as the square of the sine of the latitude in passing from the equator to the poles. This is the remarkable theorem of Stokes,[2] and it enables us to determine the form, or ellipticity of the earth, by means of pendulum observations alone. It must be admitted, however, that the values of the ellipticity recently obtained in this way by the highest author-

[1] "Toute l'Astronomie repose sur l'invariabilité de l'axe de rotation de la Terre à la surface du sphéroïde terrestre et sur l'uniformité de cette rotation." Mécanique Céleste (Paris, 1882) Tome 5, p. 22.

[2] Stokes, G. G., Mathematical and Physical Papers, Cambridge University Press, 1880, Vol. II.

ities, Clarke[1] and Helmert,[2] are far from satisfactory, whether we regard them in the light of their discrepancy or in the light of the different methods of computing them. In general terms we may say that the difficulty in the way of the use of pendulum observations still hinges on the treatment of local anomalies and on the question of reduction to sea-level. At present, the case is one concerning which the doctors agree neither in their diagnosis nor in their remedies.

Turning attention now from the surface towards the interior, what can be said of the earth's mass as a whole, of its laws of distribution, and of the pressures that exist at great depths? Two facts, namely, the mean density and the surface density, are roughly known; a third fact, namely, the precession constant, or the ratio of the difference of the two principal moments of inertia to the greater of them, is known with something like precision. These facts lie within the domain of observation and require only the law of gravitation for their verification. Certain inferences, also, from these facts and others, have long been and still are held to be hardly less cogent and trustworthy, but before stating them it will be well to recall briefly the progress of opinion concerning this general subject during the past century and a half.

The conception of the earth as having been primitively fluid was the prevailing one among mathematicians before Clairaut published his Théorie de la Figure de la Terre in 1743. By the aid of this conception Clairaut proved the celebrated theorem which bears his name, and probably no idea in the mechanics of the earth has been more suggestive and fruitful. It was the central idea in the elaborate investigations of Laplace and received at his hands a development which his successors have found it about equally difficult to displace or to improve. From the idea of fluidity spring naturally the hydrostatical notions of pressure and level surfaces, or the arrangement of fluid masses in strata of uniform density. Hence follows, also, the notion of continuity of increase in density from the surface toward the center of the earth. All of the principal mechanical properties and effects of the earth's mass, viz., the ellipticity, the surface density, the mean density, the precession con-

[1] Geodesy, Chap. XIV.

[2] Helmert, Dr. F. R., Die Mathematischen und Physikalischen Theorieen der Höheren Geodäsie. Leipzig, 1880, 1884, II Teil.

stant, and the lunar inequalities, were correlated by Laplace[1] in a single hypothesis, involving only one assumption in addition to that of original fluidity and the law of gravitation. This assumption relates to the compressibility of matter and asserts that the ratio of the increment of pressure to the increment of density is proportional to the density. Many interesting and striking conclusions follow readily from this hypothesis, but the most interesting and important are those relative to density and pressure, especially the latter, whose dominance as a factor in the mechanics of celestial masses seems destined to survive whether the hypothesis stands or falls. The hypothesis requires that while the density increases slowly from something less than 3 at the surface to about 11 at the center of the earth, the pressure within the mass increases rapidly below the surface, reaching a value surpassing the crushing strength of steel at the depth of a few miles and amounting at the center to no less than three million atmospheres. The inferences, then, as distinguished from facts, are that the mass of the earth is very nearly symmetrically disposed about its center of gravity, that pressure and density except near the surface are mutually dependent, and that the earth in reaching this stage has passed through the fluid or quasi-fluid state.

Later writers have suggested other hypotheses for a continuous distribution of the earth's mass, but none of them can be said to rival the hypothesis of Laplace. Their defects lie either in not postulating a direct connection between density and pressure or in postulating a connection which implies extreme or impossible values for these and other mechanical properties of the mass.

It is clear from the positiveness of his language in frequent allusions to this conception of the earth, that Laplace was deeply impressed with its essential correctness. "Observations," he says, "prove incontestably that the densities of the strata (couches) of the terrestrial spheroid increase from the surface to the center,"[2] and "the regularity with which the observed variation in length of a seconds pendulum follows the law of the squares of the sines of the latitudes, proves that the strata are arranged symmetrically

[1] Mécanique Céleste, Tome 5, Livre XI.

[2] "Enfin il (Newton) regarde la Terre comme homogène, ce qui est contraire aux observations, qui prouvent incontestablement que les densités des couches du sphéroïde terrestre croissent de la surface au centre." Mécanique Céleste, Tome 5, p. 9.

about the center of gravity of the earth."[1] The more recent investigations of Stokes, to which allusion has already been made, forbid our entertaining anything like so confident an opinion of the earth's primitive fluidity or of a symmetrical and continuous arrangement of its strata. But, though it must be said that the sufficiency of Laplace's arguments has been seriously impugned, we can hardly think the probability of the correctness of his conclusions has been proportionately diminished.

Suppose, however, that we reject the idea of original fluidity. Would not a rotating mass of the size of the earth assume finally the same aspects and properties presented by our planet? Would not pressure and centrifugal force suffice to bring about a central condensation and a symmetrical arrangement of strata similar at least to that required by the Laplacian hypothesis? Categorical answers to these questions cannot be given at present. But whatever may have been the antecedent condition of the earth's mass, the conclusion seems unavoidable that at no great depth the pressure is sufficient to break down the structural characteristics of all known substances, and hence to produce viscous flow whenever and wherever the stress difference exceeds a certain limit, which cannot be large in comparison with the pressure. Purely observational evidence, also, of a highly affirmative kind in support of this conclusion, is afforded by the remarkable results of Tresca's experiments on the flow of solids and by the abundant proofs in geology of the plastic movements and viscous flow of rocks. With such views and facts in mind the fluid stage, considered indispensable by Laplace, does not appear necessary to the evolution of a planet, even if it reach the extreme refinement of a close fulfilment of some such mathematical law as that of his hypothesis. If, as is here assumed, pressure be the dominant factor in such large masses, the attainment of a stable distribution would be simply a question of time. The fluid mass might take on its normal form in a few days or a few months, whereas the viscous mass might require a few thousand or a few million years.

Some physicists and mathematicians, on the other hand, reject

[1] "La régularité avec laquelle la variation observée des longueurs du pendule à secondes suit la loi du carré du sinus de la latitude prouve que ces couches sont disposées régulièrement autour du centre de gravité de la Terre et que leur forme est à peu près elliptique et de révolution." Ibid, p. 17.

both the idea of existence of great pressures within the earth's mass, and the notion of an approach to continuity in the distribution of density. As representing this side of the question the views of the late M. Roche, who wrote much on the constitution of the earth, are worthy of consideration. He tells us that the very magnitude of the central pressure computed on the hypothesis of fluidity is itself a peremptory objection to that hypothesis.[1] According to his conception, the strata of the earth from the center outwards are substantially self supporting and unyielding. It does not appear, however, that he had submitted this conception to the test of numbers, for a simple calculation will show that no materials of which we have any knowledge would sustain the stress in such shells or domes. If the crust of the earth were self supporting, its crushing strength would have to be about thirty times that of the best cast steel or five hundred to one thousand times that of granite. The views of Roche on the distribution of the terrestrial densities appear equally extreme.[2] He prefers to consider the mass as made up of two distinct parts, an outer shell or crust whose thickness is about one-sixth of the earth's radius, and a solid nucleus having little or no central condensation. The nucleus is conceived to be purely metallic and to have about the same density as iron. To account for geological phenomena, he postulates a zone of fusion separating the crust from the nucleus. The whole hypothesis is consistently worked out in conformity with the requirements of the ellipticity, the superficial density, the mean density, and precession; so that to one who can divest his mind of the notion that pressure and continuity are important factors in the mechanics of such masses, the picture which Roche draws of the constitution of our planet will present nothing incongruous.

In a field so little explored and so inaccessible, though hedged about as we have seen by certain sharply limiting conditions, there is room for a wide range of opinion and for great freedom in the play of hypothesis; and although the preponderance of evidence appears to be in favor of a terrestrial mass in which the reign of pressure is well nigh absolute, we should not be surprised a few decades or centuries hence to find many of our notions on this subject radically defective.

[1]Mémoire sur L'État Intérieur du Globe Terrestre, par M. Édouard Roche; Mémoires de la section des Sciences de l'Académie des Sciences et Lettres de Montpellier, 1880-1884, Tome X.

[2]Ibid.

If the problem of the constitution and distribution of the earth's mass is yet an obscure and difficult one after two centuries of observation and investigation, can we report any greater degree of success in the treatment of that still older problem of the earth's internal heat, of its origin and effects? Concerning phenomena always so impressive and often so terribly destructive as those intimately connected with the terrestrial store of heat, it is natural that there should be a considerable variety of opinion. The consensus of such opinion, however, has long been in favor of the hypothesis that heat is the active cause of many and a potent factor in most of the grander phenomena which geologists assign to the earth's crust; and the prevailing interpretation of these phenomena is based on the assumption that our planet is a cooling sphere whose outer shell or crust is constantly cracked and crumpled in adjusting itself to the shrinking nucleus.

The conception that the earth was originally an intensely heated and molten mass appears to have first taken something like definite form in the minds of Leibnitz and Descartes.[1] But neither of these philosophers was armed with the necessary mathematical equipment to subject this conception to the test of numerical calculation. Indeed it was not fashionable in their day, any more than it is with some philosophers in ours, to undertake the drudgery of applying the machinery of analysis to the details of an hypothesis. Nearly a century elapsed before an order of intellects capable of dealing with this class of questions appeared. It was reserved for Joseph Fourier to lay the foundation and build a great part of the superstructure of our modern theory of heat diffusion, his avowed desire being to solve the great problem of terrestrial heat. "The question of terrestrial temperatures," he says, "has always appeared to us one of the grandest objects of cosmological studies, and we have had it principally in view in establishing the mathematical theory of heat."[2] This ambition, however, was only partly realized. Probably Fourier underestimated the difficulties of his problem, for his most ingenious and industrious successors in the

[1] Protogée, ou De La Formation et des Révolutions du Globe, par Leibnitz, Ouvrage traduite . . . . . . avec une introduction et des notes par Le Dr. Bertrand de Saint Germain, Paris, 1859.

[2] "La question des températures terrestres nous a toujours paru un des plus grands objects des études cosmologiques, et nous l'avions principalement en vue en établissant la théorie mathématique de la chaleur." Annales de Chimie et de Physique, 1824, Tome 27, p. 159.

same field have made little progress beyond the limits he attained. But the work he left is a perennial index to his genius. Though quite inadequately appreciated by his contemporaries, the Analytical Theory of Heat which appeared in 1820 is now conceded to be one of the epoch-making books. Indeed, to one who has caught the spirit of the extraordinary analysis which Fourier developed and illustrated by numerous applications in this treatise, it is evident that he opened a field whose resources are still far from being exhausted. A little later Poisson took up the same class of questions and published another great work on the mathematical theory of heat.[1] Poisson narrowly missed being the foremost mathematician of his day. In originality, in wealth of mathematical resources, and in breadth of grasp of physical principles he was the peer of the ablest of his contemporaries. In lucidity of exposition it would be enough to say that he was a Frenchman, but he seems to have excelled in this peculiarly national trait. His contributions to the theory of heat have been somewhat overshadowed in recent times by the earlier and perhaps more brilliant researches of Fourier, but no student can afford to take up that enticing though difficult theory without the aid of Poisson as well as Fourier.

It is natural, therefore, that we should enquire what opinions these great masters in the mathematics of heat diffusion held concerning the earth's store of heat. I say opinions, for, unhappily, this whole subject is still so largely a matter of opinion that, in discussing it, one may not inappropriately adopt the famous caution of Marcus Aurelius— "Remember that all is opinion." It does not appear that Fourier reached any definite conclusion on this question, though he seems to have favored the view that the earth in cooling from an earlier state of incandescence reached finally through convection, a condition in which there was a uniform distribution of heat throughout its mass. This is the *consistentior status* of Leibnitz, and it begins with the formation of the earth's crust if not with the consolidation of the entire mass. It thus affords an initial distribution of heat and an epoch from which analysis may start, and the problem for the mathematician is to assign the subsequent distribution of heat and the resulting mechanical effects. But no great amount of reflection is necessary to convince one that the analysis cannot proceed without making a few more

[1]Théorie Mathématique de la Chaleur, Paris, 1835.

assumptions. The assumptions which involve the least difficulty, and which for this reason, partly, have met with most favor, are that the conductivity and thermal capacity of the entire mass remain constant, and that the heat conducted to the surface of the earth passes off by the combined process of radiation, convection, and conduction, without producing any sensible effect on surrounding space. These or similar assumptions must be made before the application of theory can begin. In addition, two data are essential to numerical calculations, namely, the diffusivity, or ratio of the conductivity of the mass to its thermal capacity, and the initial uniform temperature. The first of these can be observed, approximately, at least; the second can only be estimated at present. With respect to these important points which must be considered after the adoption of the *consistentior status*, the writings of Fourier afford little light. He was content, perhaps, to invent and develop the exquisite analysis requisite to the treatment of such problems.

Poisson wrote much on the whole subject of terrestrial temperatures and carefully considered most of the troublesome details which lay between his theory and its application. While he admitted the nebular hypothesis and an initial fluid state of the earth, he rejected the notion that the observed increase of underground temperature is due to a primitive store of heat. If the earth was originally fluid by reason of its heat, a supposition which Poisson regarded quite gratuitous, he conceived that it must cool and consolidate from the center outwards;[1] so that according to this view the crust of our planet arrived at a condition of stability only after the supply of heat had been exhausted. But Poisson was not at a loss to account for the observed temperature gradient in the earth's crust. Always fertile in hypotheses, he advanced the idea that there exist by reason of interstellar radiations, great variations in the temperature of space, some vast regions being comparatively cool and others intensely hot, and that the present store of terrestrial heat was acquired by a journey of the solar system through one of the hotter regions. "Such is," he says, "in my opinion, the true cause of the augmentation of temperature which occurs as we descend below the surface of the globe."[2] This hypothesis was the

[1]Théorie Mathématique de la Chaleur, Supplement de, Paris, 1837.

[2]"Telle est, dans mon opinion, la cause véritable de l'augmentation de température qui a lieu sur chaque verticale à mesure que l'on s'abaisse au-dessous de la surface du globe." Théorie Mathématique de la Chaleur, Supplement de, p. 15.

result of Poisson's mature reflection and as such is well worthy of attention. The notion that there exist hot foci in space was advanced also in another form in 1852 by Rankine, in his interesting speculation on the reconcentration of energy. But whatever we may think of the hypothesis as a whole it does not appear to be adequate to the case of the earth unless we suppose the epoch of transit through the hot region exceedingly remote and the temperature of that region exceedingly high. The continuity of geological and paleontological phenomena is much better satisfied by the Leibnitzian view of an earth long subject to comparatively constant surface conditions but still active with the energy of its primitive heat.

Notwithstanding the indefatigable and admirable labors of Fourier and Poisson in this field, it must be admitted that they accomplished little more than the preparation of the machinery with which their successors have sought and are still seeking to reap the harvest. The difficulties which lay in their way were not mathematical but physical. Had they been able to make out the true conditions of the earth's store of heat, they would undoubtedly have reached a high grade of perfection in the treatment of the problem. The theory as they left it was much in advance of observation, and the labors of their successors have therefore necessarily been directed largely towards the determination of the thermal properties of the earth's crust and mass.

Of those who in the present generation have contributed to our knowledge and stimulated the investigation of this subject, it is hardly necessary to say that we owe most to Sir William Thomson. He has made the question of terrestrial temperatures highly attractive and instructive to astronomers and mathematicians, and not less warmly interesting to geologists and paleontologists. Whether we are prepared to accept his conclusions or not, we must all acknowledge our indebtedness to the contributions of his master hand in this field as well as in most other fields of terrestrial physics. The contribution of special interest to us in this connection is his remarkable memoir on the secular cooling of the earth.[1] In this memoir he adopts the simple hypothesis of a solid sphere whose thermal properties remain invariable while it cools by con-

[1]Transactions of the Royal Society of Edinburgh, 1862. Thomson and Tait's Natural Philosophy, Vol. 1, Part II, Appendix D.

duction from an initial state of uniform temperature, and draws therefrom certain striking limitations on geologic time. Many geologists were startled by these limitations and geologic thought and opinion have since been widely influenced by them. It will be of interest therefore to state a little more fully and clearly the grounds from which his arguments proceed. Conceive a sphere having a uniform temperature initially, to cool in a medium which instantly dissipates all heat brought by conduction to its surface, thus keeping the surface at a constant temperature. Suppose we have given the initial excess of the sphere's temperature over that of the medium. Suppose also that the capacity of the mass of the sphere for the diffusion of heat is known, and known to remain invariable during the process of cooling. This capacity is called diffusivity and is a constant which can be observed. Then from these data, the distribution of temperature at any future time can be assigned, and hence also the rate of temperature increase, or the temperature gradient, from the surface towards the center of the sphere can be computed. It is tolerably certain that the heat conducted from the interior to the surface of the earth does not set up any reaction which in any sensible degree retards the process of cooling. It escapes so freely that, for practical purposes, we may say it is instantly dissipated. Hence if we can assume that the earth had a specified uniform temperature at the initial epoch, and can assume its diffusivity to remain constant, the whole history of cooling is known so soon as we determine the diffusivity and the temperature gradient at any point. Now Sir William Thomson determined a value for the diffusivity from measurements of the seasonal variations of underground temperatures, and numerous observations of the increase of temperature with depth below the earth's surface gave an average value for the temperature gradient. From these elements and from an assumed initial temperature of 7000° Fahr., he infers that geologic time is limited to something between twenty million and four hundred million years. He says: "We must allow very wide limits in such an estimate as I have attempted to make; but I think we may with much probability say that the consolidation cannot have taken place less than 20,000,000 years ago, or we should have more underground heat than we actually have, nor more than 400,000,000 years ago, or we should not have so much as the least observed underground increment of temperature. That is to say, I conclude that Leibnitz's epoch of emergence of

the *consistentior status* was probably between those dates." These conclusions were announced twenty-seven years ago and were republished without modification in 1883. Recently, also, Professor Tait, reasoning from the same basis, has insisted with equal confidence on cutting down the upper limit of geologic time to some such figures as ten million or fifteen million years.[1] As mathematicians and astronomers we must all confess to a deep interest in these conclusions and the hypothesis from which they flow. They are very important if true. But what are the probabilities? Having been at some pains to look into this matter, I feel bound to state that, although the hypothesis appears to be the best which can be formulated at present, the odds are against its correctness. Its weak links are the unverified assumptions of an initial uniform temperature and a constant diffusivity. Very likely these are approximations, but of what order we cannot decide. Futhermore, if we accept the hypothesis, the odds appear to be against the present attainment of trustworthy numerical results, since the data for calculation, obtained mostly from observations on continental areas, are far too meagre to give satisfactory average values for the entire mass of the earth. In short, this phase of the case seems to stand about where it did twenty years ago, when Huxley warned us that the perfection of our mathematical mill is no guaranty of the quality of the grist, adding that, "as the grandest mill will not extract wheat-flour from peas-cods, so pages of formulæ will not get a definite result out of loose data."[2]

When we pass from the restricted domain of quantitative results concerning geologic time to the freer domain of qualitative results of a general character, the contractional theory of the earth may be said still to lead all others, though it seems destined to require more or less modification if not to be relegated to a place of secondary importance. Old, however, as is the notion that the great surface irregularities of the earth are but the outward evidence of a crumpling crust, it is only recently that this notion has been subjected to mathematical analysis on anything like a rational basis. About three years ago, Mr. T. Mellard Reade[3] announced the doctrine that the earth's crust from the joint effect of its heat and gravitation should behave in a way somewhat analogous to a bent beam,

[1]Recent Advances in Physical Science, London, 1876.
[2]Geological Reform (The Anniversary Address to the Geological Society for 1869).
[3]Reade, T. Mellard, Origin of Mountain Ranges, London, 1886.

and should possess at a certain depth a "level of no strain" corresponding to the neutral surface in a beam. Above the level of no strain, according to this doctrine, the strata will be subjected to compression and will undergo crumpling, while below that level the tendency of the strata to crack and part is overcome by pressure which produces what Reade calls " compressive extension, thus keeping the nucleus compact and continuous. A little later, the same idea was worked out independently by Mr. Charles Davison,[1] and it has since received elaborate mathematical treatment at the hands of Darwin,[2] Fisher,[3] and others. The doctrine requires for its application a competent theory of cooling and hence cannot be depended on at present to give anything better than a general idea of the mechanics of crumpling and a rough estimate of the magnitudes of the resulting effects. Using Thomson's hypothesis, it appears that the stratum of no strain moves downward from the surface of the earth at a nearly constant rate during the earlier stages of cooling, but more slowly during later stages; its depth is independent of the initial temperature of the earth; and if we adopt Thomson's value of the diffusivity, it will be about two and a third miles below the surface in a hundred million years from the beginning of cooling, and a little more than fourteen miles below the surface in seven hundred million years. The most important inference from this theory is that the geological effects of secular cooling will be confined for a very long time to a comparatively thin crust. Thus, if the earth is a hundred million years old, crumpling should not extend much deeper than two miles. A test to which the theory has been subjected, and one which some[4] consider crucial against it, is the volumetric amount of crumpling shown by the earth at the present time. This is a difficult quantity to estimate, but it appears to be much greater than the theory can account for.

The opponents of the contractional theory of the earth, believing it quantitatively insufficient, have recently revived and elaborated an idea first suggested by Babbage and Herschel[5] in explanation of

[1] On the Distribution of Strain in the Earth's Crust resulting from Secular Cooling; with special reference to the growth of continents and the formation of mountain chains. By Charles Davison, with a Note by G. H. Darwin. Philosophical Transactions, Vol. 178 (1887), A, pp. 231-249.

[2] Ibid.

[3] Fisher, Rev. Osmond, Physics of the Earth's Crust, second edition, London, 1889, Chapter VIII.

[4] Notably Rev. Osmond Fisher. See his Physics of the Earth's Crust, Chapter VIII.

[5] Appendix to the Ninth Bridgewater Treatise (By C. Babbage), second edition, London, 1838.

the greater folds and movements of the crust. This idea figures the crust as being in a state bordering on hydrostatic equilibrium which cannot be greatly disturbed without a readjustment and consequent movement of the masses involved. According to this view, the transfer of any considerable load from one area to another is followed sooner or later by a depression over the loaded area and a corresponding elevation over the unloaded one; and in a general way it is inferred that the elevation of continental areas tends to keep pace with erosion. The process by which this balance is maintained has been called isostasy,[1] and the crust is said to be in an isostatic state. The dynamics of the superficial strata with the attendant phenomena of folding and faulting are thus referred to gravitation alone, or to gravitation and whatever opposing force the rigidity of the strata may offer. In a mathematical sense, however, the theory of isostasy is in a less satisfactory state than the theory of contraction. As yet we can see only that isostasy is an efficient cause if once set in action; but how it is started and to what extent it is adequate remain to be determined. Moreover, isostasy does not seem to meet the requirements of geological continuity, for it tends rapidly towards stable equilibrium, and the crust ought therefore to reach a state of repose early in geologic time. But there is no evidence that such a state has been attained, and but little if any evidence of diminished activity in crustal movements during recent geologic time. Hence we infer that isostasy is competent only on the supposition that it is kept in action by some other cause tending constantly to disturb the equilibrium which would otherwise result. Such a cause is found in secular contraction, and it is not improbable that these two seemingly divergent theories are really supplementary.

Closely related to the questions of secular contraction and the mechanics of crust movements are those vexed questions of earthquakes, volcanism, the liquidity or solidity of the interior, and the rigidity of the earth's mass as a whole—all questions of the greatest interest, but still lingering on the battle-fields of scientific opinion. Many of the "thrice slain" combatants in these contests would fain risk being slain again; and whether our foundation be liquid or solid, or to speak more precisely, whether the earth may not be at once highly plastic under the action of long continued

[1] Dutton, Capt. C. E. On some of the Greater Problems of Physical Geology, Bulletin Philosophical Society of Washington, Vol. XI, pp. 51–64.

forces and highly rigid under the action of periodic forces of short period, it is pretty certain that some years must elapse before the arguments will be convincing to all concerned. The difficulties appear to be due principally to our profound ignorance of the properties of matter subject to the joint action of great pressure and great heat. The conditions which exist a few miles beneath the surface of the earth are quite beyond the reach of laboratory tests as hitherto developed, but it is not clear how our knowledge is to be improved without resort to experiments of a scale in some degree comparable with the facts to be explained. In the meantime, therefore, we may expect to go on theorizing, adding to the long list of dead theories which mark the progress of scientific thought, with the hope of attaining the truth not so much by direct discovery as by the laborious process of eliminating error.

When we take a more comprehensive view of the problems presented by the earth, and look for light on their solution in theories of cosmogony, the difficulties which beset us are no less numerous and formidable than those encountered along special lines of attack. Much progress has recently been made, however, in the elaboration of such theories. Roche,[1] Darwin,[2] and others have done much to remove the nebulosity of Laplace's nebular hypothesis. Poincaré[3] and Darwin[4] have gone far towards bridging the gaps which have long rendered the theory of rotating fluid masses incomplete. Poincaré has, in fact, shown us how a homogeneous rotating mass might, through loss of heat and consequent contraction, pass from the spheroidal form to the Jacobian ellipsoidal form, and thence, by reason of its increasing speed of rotation, separate into two unequal masses. Darwin, starting with a swarm of meteorites and gravitation as a basis, has reached many interesting and instructive results in the endeavor to trace out the laws of evolution of a planetary system.[5] But notwithstanding the splendid researches of

[1]Essai sur la Constitution et L'Origine du Système Solaire, par M. Édouard Roche. Mémoires de L'Académie des Sciences et Lettres de Montpellier, Tome VIII, 1873.

[2]On the Precession of a Viscous Spheroid and on the remote History of the Earth, Phil. Trans., Part II, 1879. On the secular changes in the Elements of the Orbit of a Satellite revolving about a tidally distorted Planet, Phil. Trans., Part II, 1880. On the Tidal Friction of a Planet attended by several Satellites, and on the Evolution of the Solar System, Phil. Trans., Part II, 1881.

[3]Sur L'Équilibre d'une Masse Fluide animée d'un mouvement de rotation, Acta Mathematica, Vol. 7, 1885.

[4]On Figures of Equilibrium of Rotating Masses of Fluid, Phil. Trans., Vol. 178, 1887.

[5]On the Mechanical Conditions of a Swarm of Meteorites and on Theories of Cosmogony, Phil. Trans., Vol. 180, 1889.

these and other investigators in this field, it must be said that the real case of the solar system, or of the earth and the moon, still defies analysis; and that the mechanics of the segregation of a planet from the sun, or of a satellite from a planet, if such an event has ever happened, or the mechanics of the evolution of a solar system from a swarm of meteorites, are still far from being clearly made out.

Time does not permit me to make anything but the briefest allusion to the comparatively new science of mathematical meteorology with its already considerable list of well defined theories pressing for acceptance or rejection. Nor need I say more with reference to those older mathematical questions of the tides and terrestrial magnetism than that they are still unsettled. These and many other questions, old and new, might serve equally well to illustrate the principal fact this address has been designed to emphasize, namely, that the mathematical theories of the earth already advanced and elaborated are by no means complete, and that no mathematical Alexander need yet pine for other worlds to conquer.

Speculations concerning the course and progress of science are usually untrustworthy if not altogether fallacious. But, being delegated for the hour to speak to and for mathematicians and astronomers, it may be permissible to offer, in closing, a single suggestion, which will perhaps help us to orient ourselves aright in our various fields of research. If the curve of scientific progress in any domain of thought could be drawn, there is every reason to believe that it would exhibit considerable irregularities. There would be marked maxima and minima in its general tendency towards the limit of perfect knowledge; and it seems not improbable that the curve would show throughout some portions of its length a more or less definitely periodic succession of maxima and minima. Races and communities as well as individuals, the armies in pursuit of truth as well as those in pursuit of plunder, have their periods of culminating activity and their periods of placid repose. It is a curious fact that the history of the mathematical theories of the earth presents some such periodicity. We have the marked maximum of the epoch of Newton near the end of the seventeenth century, with the equally marked maximum of the epoch of Laplace near the end of the eighteenth century; and, judging from the recent revival of geodesy and astronomy in Europe, and from the well nigh general activity in mathematical and geological research, we may hope if not expect that

the end of the present century will signalize a similar epoch of productive activity. The minima periods which followed the epochs of Newton and Laplace are less definitely marked but not less noteworthy and instructive. They were not periods of placid repose; to find such one must go back into the night of the middle ages; but they were periods of greatly diminished energy, periods during which those who kept alive the spirit of investigation were almost as conspicuous for their isolation as for their distinguished abilities. Many causes, of course, contributed to produce these minima periods, and it would be an interesting study in philosophic history to trace out the tendency and effect of each cause. It is desired here, however, to call attention to only one cause which contributed to the somewhat general apathy of the periods mentioned, and which always threatens to dampen the ardor of research immediately after the attainment of any marked success or advance. I refer to the impression of contentment with and acquiescence in the results of science, which seems to find easy access to trained as well as untrained minds before an investigation is half completed or even fairly begun. That some such tacit persuasion of the completeness of the knowledge of the earth has at times pervaded scientific thought, there can be no doubt. This was notably the case during the period which followed the remarkable epoch of Laplace. The profound impression of the sufficiency of the brilliant discoveries and advances of that epoch is aptly described by Carlyle in the half humorous, half sarcastic language of Sartor Resartus. "Our Theory of Gravitation," he says, "is as good as perfect: Lagrange, it is well known, has proved that the Planetary System, on this scheme, will endure forever; Laplace, still more cunningly, even guesses that it could not have been made on any other scheme. Whereby, at least, our nautical Logbooks can be better kept; and water transport of all kinds has grown more commodious. Of Geology and Geognosy we know enough; what with the labors of our Werners and Huttons, what with the ardent genius of their disciples, it has come about that now, to many a Royal Society, the creation of a World is little more mysterious than the cooking of a dumpling; concerning which last, indeed, there have been minds to whom the question *How the apples were got in*, presented difficulties." This was written nearly sixty years ago, about the time the sage of Ecclefechan abandoned his mathematics and astronomy for literature to become the seer of Chelsea; but the force of its irony is still applicable, for

we have yet to learn, essentially, "*How the apples were got in*" and what kind they are.

As to the future we can only guess, less or more vaguely, from our experience in the past and from our knowledge of present needs. Though the dawn of that future is certainly not heralded by rosy tints of over-confidence amongst those acquainted with the difficulties to be overcome, the prospect on the whole has never been more promising. The converging lights of many lines of investigation are now brought to bear on the problems presented by our planet. There is ample reason to suppose that our day will witness a fair average of those happy accidents in science which lead to the discovery of new principles and new methods. We have much to expect from the elaborate machinery and perfected methods of the older and more exact sciences of measuring and weighing—astronomy, geodesy, physics and chemistry. We have more to expect, perhaps, from geology and meteorology with their vast accumulations of facts not yet fully correlated. Much, also, may be anticipated from that new astronomy which looks for the secrets of the earth's origin and history in nebulous masses or in swarms of meteorites. We have the encouraging stimulus of a very general and rapidly growing popular concern in the objects of our enquiries, and the freest avenues for the dissemination of new information; so that we may easily gain the advantage of a concentration of energy without centralization of personal interests. To those, therefore, who can bring the prerequisites of endless patience and unflagging industry, who can bear alike the remorseless discipline of repeated failure and the prosperity of partial success, the field is as wide and as inviting as it ever was to a Newton or a Laplace.

PAPERS READ.

THE RELATION BETWEEN STELLAR MAGNITUDES, DISTANCES AND MOTIONS.

By Prof. J. R. EASTMAN, U. S. Naval Observatory, Washington, D. C.

[ABSTRACT.]

IN all investigations of the direction and velocity of the motion of the solar system, certain assumptions have always been made in regard to the relative distances of the stars from the sun, and the basis of most of these assumptions is the idea that the magnitude of the star is an index to its distance from the solar system. The first well considered scheme for expressing the relations between stellar magnitudes and distances was devised by F. G. W. Struve in 1827 and it has been tacitly followed since that time. Struve's relations are expressed in the table below:

MAGNITUDES.	1	2	3	4	5	6	7
DISTANCES.	1	1.71	2.57	3.76	5.44	7.86	11.34

If this table be extended it would give the distance for eighth magnitudes stars about 16.5 and ninth magnitudes about 28 ±.

The modern determinations of stellar parallax and proper motion throw grave doubts upon such relations as have been generally assumed.

In his Inaugural Dissertation at Bonn in 1884 Dr. Johann Bischof discussed the proper motions of 345 stars observed by Argelander, including Argelander's well-known list of 250 proper motion stars. This list contains stars from the fifth to the ninth magnitude.

I have divided Bischof's list into four classes, as follows: In the first class are the stars whose proper motions are greater than 1″.0; the second class contains those whose motions are between 0″.701 and 1″.000; the third class those whose motions are between 0″.401 and 0″.700 and the fourth class those with motions less than 0″.401, and the results are given below:

TABLE I.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
Class I	19	7.83	″ 1.908
" II	24	7.71	0.825
" III	65	7.42	0.516
" IV	237	7.17	0.246

To show that the agreement in the magnitudes is not accidental I have divided the number of stars in the third class into two groups *seriatim* and those in the fourth class into six groups as shown below.

TABLE II.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			"
Class III, group 1	33	7.38	0.533
" " " 2	32	7.46	0.498
Class IV, group 1	40	7.23	0.260
" " " 2	40	7.29	0.274
" " " 3	40	7.04	0.235
" " " 4	39	7.24	0.249
" " " 5	39	7.20	0.234
" " " 6	39	7.03	0.226

This shows conclusively that the results for mean magnitude and mean proper motion are entirely free from accidental variations.

In order to extend the examination to stars of greater magnitude I have collated the proper motions of the 307 stars larger than the fifth magnitude contained in Newcomb's Catalogue of Standard Clock and Zodiacal Stars, Astronomical Papers of the American Ephemeris, 1882. These were divided into four groups according to the same method used with Argelander's stars and the results are given below.

TABLE III.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
			"
Class I	8	2.41	2.278
" II	5	3.54	0 841
" III	10	2.76	0.526
" IV	284	3.66	0.099

In order to test the uniformity of the results in Class IV the stars were divided into five nearly equal groups with the result as given below.

TABLE IV.

	NUMBER OF STARS.	MEAN MAGNITUDE.	MEAN PROPER MOTION.
Class IV, Group 1	57	3.77	0.104″
" " " 2	57	3.56	.087
" " " 3	57	3.51	.110
" " " 4	57	3.60	.097
" " " 5	56	3.84	.098

This table shows the same freedom from accidental variations as table II. The four tables also show, that, with the exception of the few stars about the first magnitude, the proper motion does not decrease with the decrease in the magnitude but as in table I the proper motion is *greatest* for the smaller stars. This is still more prominently shown in the following table. I have separated the 652 stars, including those of Bischof's and Newcomb's lists, into groups according to magnitude.

I have tabulated as *first* magnitudes all stars greater than 1.5 mag.; as *second* those between 1.6 mag. and 2.5 mag. inclusive; as *third* those between 2.6 mag. and 3.5 mag.; as *fourth* those between 3.6 mag. and 4 5 mag.; as *fifth* those between 4.6 mag. and 5.5 mag.; as *sixth* those between 5.6 mag. and 6.5 mag.; as *seventh* those between 6.6 mag. and 7.5 mag.; as *eighth*, those between 7.6 mag. and 8.5 mag. and as *ninth* all those fainter than 8.6 mag. inclusive. These are exhibited below.

TABLE V.

NUMBER OF STARS.	MEAN MAGNITUDE OF GROUP.	MEAN PROPER MOTION OF GROUP.
18	1.11	0.524″
44	2.15	0.161
67	3.07	0.181
98	4.05	0.141
90	4.87	0.172
64	6.12	0.292
128	7.05	0.421
114	8.08	0.460
29	8.78	0.678

On the solar parallax and its related constants. By Prof. Wm. Harkness, Washington, D. C.

[This paper consisted of a brief account of an investigation soon to be published by the U. S. Naval Observatory.]

The polar tractrix. By Prof. J. Burkitt Webb, Stevens Institute, Hoboken, N. J.

[abstract.]

In connection with Amsler's Planimeter,[1] Sir Robert Ball has pointed out that the pointer may be made to trace such a curve as to produce no motion of the registering wheel. Some years ago, in writing a discussion of this planimeter the formula for such a curve was developed and has not been met with elsewhere.

The planimeter consists of an arm OP, pivoted at O to a flat surface, on which is drawn any curve whose area is to be determined. A second arm, PQ, is pivoted to the first, and its opposite end Q is furnished with a pointer, which is passed completely around the curve in the process of measuring its area. The pointer and the axes of the pivots are all parallel to each other and perpendicular to the plane surface. To the arm PQ are attached journals in which a measuring wheel runs, whose axis is parallel to the line PQ. This wheel may occupy any position with regard to the points PQ. It turns freely in its journals and rests with a narrow edge and some friction upon the surface, so that during the motion of the pointer it is revolved one way or the other by the friction, and this revolution is read off by means of suitable graduations on its perimeter, which reading also gives the area.

Let p be the point where the plane of the wheel cuts PQ, and W the point of contact of the wheel with the paper, then the motion of the wheel is independent of the distance Wp and we may suppose a planimeter in which W and p coincide to be the normal form of the instrument, and designate the contact point by Wp. Instead, also, of supposing Q to trace such a curve as will cause no revolution of the wheel, it will be more direct to seek the curve which Wp must follow in that case. This curve is a "polar tractrix" and is the fundamental curve of the family of curves traced by all points (of which Q is one) connected with the arm PQ.

Dispensing then with the point Q, and thus reducing the arm PQ to $P\,Wp$ the problem is to revolve the arm $OP = c$ about O and let it drag the arm $P\,Wp = b$ after it, Wp resting with friction on the flat surface, and to find the curve traced by Wp on the surface.

One form of this curve is evidently a circle of the radius

$$r_0 = \sqrt{c^2 - b^2},$$

which is also the circular asymptote to the general form of the curve.

[1]See demonstration of the action of this planimeter in Williamson's Calculus.

The consideration which leads to the differential equation of the curve is that Wp must move always in the line through P, or that $P\,Wp$ is always tangent to the curve.

The differential equation of the curve is

$$\rho\, d\gamma + b\, d\beta = 0$$

in which ρ is the perpendicular from O upon the plane of the wheel and γ and β, the respective angles made by the arms OP with a prime radius through O and $P\,Wp$ with OP.

The resulting equation of the curve is, when the prime radius is chosen so as to be an axis of symmetry of the curve, in which case $\gamma = 0$ for $\beta = 0$,

$$\gamma \quad \tan \beta' = \log_e \mp \frac{\sin \dfrac{\beta + \beta'}{2}}{\sin \dfrac{\beta - \beta'}{2}}$$

where the minus and plus signs refer to two branches of the tractrix respectively within and without the asymptote or "primitive circle" and where β' is the value of β corresponding to $\rho = 0$.

If c be made equal to ∞, as in "Coffin's Averaging Instrument" the curve becomes the common tractrix.

The form of the curve is that of two right handed and two left handed spirals, which are symmetrically placed with respect to the prime radius and which meet in two cusps at points upon it distant respectively $c - b$ and $c + b$ from O, and which after an infinite number of turns merge into the primitive circle.

The curve may be accurately drawn by a simple construction, mostly geometrical after which the curve traced by any other point (as Q) moving with $P\,Q$ is readily added.

A PRECESSION MODEL. By Prof. J. BURKITT WEBB, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

THE essential feature of the model presented for the illustration and imitation of the effect of precession is a sphere supported by jets of air, so as to be essentially free in space to rotate though not to translate. With such a model and jets of high pressure air applied so as to suitably impinge upon the surface, in connection, if preferred, with magnetic attraction, the combination of rotations in space as well as the combination of a rotation with an angular acceleration (which is the phenomenon of precession) may be produced. The sphere has also means by which its three moments of inertia may be varied at will, so as to imitate all possible masses, which provides for the production of various other phenomena.

The centrifugal catenary. By Prof. J. Burkitt Webb, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

In the governors attached to steam and other engines and in various other apparatus, springs are used under the influence of centrifugal force. The variation of the form and tension of such a spring, due to such force, may or may not be sufficiently great to measurably change the action of the spring, but cases will certainly arise in which a knowledge of the action of centrifugal force will be necessary for their satisfactory treatment. I have, therefore, investigated some of the curves assumed by elastic and non-elastic chains in a field of centrifugal force, the former representing spiral springs whose lateral stiffness is neglected.

Such a curve may be called a "Centrifugal Catenary" and will belong to one of the following divisions:

Non-elastic or elastic, which may be further classified according to whether the points A and B, revolving about an axis and to which the chain is attached, are;

(*a*) in a plane passing through the axis of rotation;

(*b*) in a plane perpendicular to the axis of rotation;

(*c*) in neither.

The chain may also be either; In tension, in which case the equilibrium is stable; or in compression, which is a case of unstable equilibrium.

The chain may also be confined in various ways, as, for instance, it may be compelled to remain rectilinear and allowed only to adjust its tension to suit the centrifugal field. This is, substantially, the practical case of a short, stiff spiral spring in the fly-wheel of a steam engine and was the means of suggesting a general discussion of springs and chains in a field of centrifugal force.

It will be noticed that the curve taken by a girl's skipping rope is case (*a*) with a non-elastic chain.

A proposed catalogue of declinations (By permission of the Superintendent). By Henry Farquhar, Coast Survey Office, Washington, D. C.

[ABSTRACT.]

Reasons for recommending the formation of a catalogue of declinations, to the highest degree of precision now attainable, by the U. S. Coast Survey, including:

(1) The large number of stars whose declination are needed, for latitudes observed by the Talcott method.

(2) Proof that the greater part of the error of latitudes so observed on the Survey, results from weak declinations.

(3) Indication that a considerable improvement could be made by a more thorough systematic study of the data, given by a comparison of the probable errors of the provisional places used for Coast Survey latitudes with those of the Northern Boundary Catalogue as deduced by Boss.

(4) Necessity of care to avoid systematic error of declinations in the solution of geodetic problems; illustrated by the effect on the comparison of astronomic and geodetic latitudes at the extremities of a long arc (Eastport to Atlanta) connected by the triangulation of the Survey, of the circumstance that the observations at one end were generally later than at the other, so that the star-places contained more of whatever systematic error there was in the declination proper-motions used.

(5) Improbability that, if the Coast Survey declined this work, any other agency could be expected to undertake it.

(6) Use of such a catalogue for ends other than geodetic.

Declination Standards: account of the three different ones promulgated by Dr. Auwers.

Examination of the claims of Auwers' Bradley to be accepted as fundamental, as tested by four sets of data:

(1) Differences of declinations from stars observed above and below pole, with quadrant to north.

(2) Differences of declinations observed near zenith, in both positions of quadrant.

(3) Differences between very low observations below pole and observations in southward position of quadrant.

(4) Differences from Bessel's "Fundamenta" between $+14^\circ$ and -14° declination.

Derivation of a general formula for the correction of all Bradley's declinations, $\mp ''.63 - ''.56 \cos a - ''.02 \sin a + 2''.01 \cos \delta \pm ''.66 \sin \delta$ for northern stars at the two culminations; $-''.72 + ''.56 \cos a + ''.02 \sin a + 2''.01 \cos \delta + ''.66 \sin \delta$ for southern.

Comparison of these declinations with the Boss standard, before and after this correction.

ON THE USE OF A FLOATING MIRROR AS AN AUXILIARY TO A MERIDIAN CIRCLE. By Prof. GEO. C. COMSTOCK, Madison, Wis.

[ABSTRACT.]

THIS paper contains a description of an apparatus by which the principle of the almucantar is employed in the use of a meridian circle for the determination of horizontal points. It consists essentially of a mirror, with plane parallel faces, supported upon a platform which floats in a basin of mercury. This basin rotates about a vertical axis, and the mirror may be rotated about a horizontal axis. The method of observing is precisely

similar to that employed in ordinary observations of the nadir. By means of six pointings of the telescope, all errors of the instrument may be eliminated and experiments with the meridian circle of the Washburn Observatory show that the horizontal point may be determined with a probable error not greater than $0''.2$. By measuring the angle between the nadir and the north and south horizons the sine and cosine flexures of the meridian circle may be readily determined with a high degree of precision.

A DESIDERATUM IN THE PRESENTATION OF MATHEMATICAL TRUTH. By Prof. CHARLES H. CHANDLER, Ripon, Wis.

[ABSTRACT.]

IT is a prevalent belief that but few are so constituted as to enjoy mathematical study; and the small membership of the mathematical section of the association seems to harmonize with this view.

But it seems reasonable that a change in the methods of presenting mathematical truth in text-books or papers on original investigations might greatly modify both of these conditions. The interest in the physical and natural sciences has been greatly advanced within a few years, by that change in methods by which readers are taken, as it were, into the laboratory, and led to appreciate the motives for the several steps of the investigations in progress.

So, too, mathematical students should be shown, as they proceed, the motives for successive processes, and thus be able to recognize their advance toward clearer light, without waiting for the result to justify the course pursued.

NEW ARRANGEMENT FOR AN ASTIGMATIC EYE-PIECE. By JNO. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

IT is the purpose of this paper to describe a simple arrangement of attaching an astigmatic lens to any form of eye-piece so as to correct the astigmatism of the eye.

THE JENA OPTICAL GLASS. By JNO. A. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

IT is the purpose of this paper to give a few notes on the value of the new Jena optical glass. First, on its transparency; second, on its equal

density and perfect annealing; third, on the high value of the tables furnished with it, and fourth, on the reliability of the constants of its indices and partial dispersion; and, finally, on its permanence.

THE HASTINGS ACHROMATIC OBJECTIVE. By J. H. BRASHEAR, Allegheny, Pa.

[ABSTRACT.]

THE investigation of an objective, made by the writer from Jena glass Nos. 14 and 27, from computations made by Dr. Hastings, shows, first, that the focal length came out within a fraction of a millimetre of the computed focus; second, that spherical aberration was entirely eliminated, requiring no after work; third, that a careful spectroscopic study of its achromatism, shows (1), by Professor Harkness' method, an almost perfectly parallel spectrum, deviating only a very minute quantity in the extreme violet; and (2), by a study of artificial stars made by throwing the various colors of the spectrum upon a silvered convex surface, that the change in focus did not amount to one-fifth of a millimetre for the visible spectrum; and, fourth, that the objective will prove to be as perfect for photographic, as for visual, work.

THE PERUVIAN ARC. By E. D. PRESTON, Assistant U. S. Coast and Geodetic Survey, Washington, D. C.

[ABSTRACT.]

IN order to determine the size and shape of the earth there were measured, one hundred and fifty years ago, two meridional arcs: one in Peru and the other in Lapland.

The Peruvian work is examined in this paper with reference to the degree of accuracy attained and a comparison is made between the uncertainties of these measures and those resulting from work with modern instruments, and following more recent methods.

It is shown that the probable errors are much larger than would be indicated by the agreement of the published results, and that therefore the concordance of this arc with those in other parts of the world is no proof of its accuracy.

By far the most significant errors come from the astronomical observations and the unavoidable uncertainties here, either from the imperfection of the instruments, or the attraction of the high mountains, are shown to perceptibly affect the elements of the earth's figure now in use.

The conclusion is that geodesy to-day demands the remeasurement of this arc.

AUTOMATIC PHOTOGRAPHIC TRANSITS. By Prof. FRANK H. BIGELOW, Nautical Almanac Office, Washington, D. C.

[ABSTRACT.]

IN the history of observations of precision there are three distinct periods: (1) an English school of which John Pond is a type; (2) a German school represented by Bessel; and (3) a modern school of photography as applied to transits.

For the automatic observation of star transits by photographic record, and consequent elimination of the Personal Equation, an apparatus is described whose method and operation seem satisfactory. It is simple, and can be attached to the telescopes now used, with a little care, thus rendering them available for the old and the new method. Transits of 4° Mag. stars are obtained with a six-inch glass, and the process is so rigorous as to admit the use of the most sensitive plates.

ON THE GRADUATION OF MERIDIAN CIRCLES IN SITU. By Prof. WM. A. ROGERS, Waterville, Me.

[ABSTRACT.]

THIS paper consists of a description of the process by which a circle having a diameter of five feet was graduated to degrees with subdivisions to 2′. After the third trial the greatest error of the 6° points, *including the error of eccentricity*, was found to be within 1″.6 while the average error was only 0″.2

The circle has an axis six inches in diameter.

ON THE PROPER MOTIONS OF THE STARS IN THE HARVARD COLLEGE OBSERVATORY ZONE BETWEEN THE LIMITS OF 50° AND 55° DECLINATION. By Prof. WM. A. ROGERS, Waterville, Me.

ASTRONOMICAL OBSERVATIONS MADE WITH THE GREAT TELESCOPE OF THE LICK OBSERVATORY SINCE JUNE, 1888. By Prof. EDWARD S. HOLDEN, San José, Cal.

DOUBLE STAR DISCOVERIES AND MEASURES MADE AT THE LICK OBSERVATORY, AUGUST 1, 1888, TO AUGUST 1, 1889 BY S. W. BURNHAM, Mount Hamilton, Cal.

THE results of the double star observations during the past year are given as briefly as possible in the following pages. A few of the new double stars have appeared in No. 2875 of *Astronomische Nachrichten*. A later list has been sent to the same Journal, but not yet printed. The β numbers of these stars are given (β 1026 to β 1092). So far as possible, every star, new and otherwise, has been measured on at least three nights. The mean of these measures is given, with the number of nights in each case.

The measures have been made in the usual manner, and with micrometers of the ordinary Clark form. In an abstract of this kind, it would not be easy to indicate the instrument used in each case. In many instances, the mean is derived from measures with both the 36-inch and 12-inch refractors; but the largest part of the measures were made with the large telescope, and most of the new stars found with it. In selecting old double stars for measurement, the superior power of the 36-inch for this class of work has been borne in mind, and objects too difficult to be observed with ordinary instruments, and pairs which for many years have been regarded as single, have been chosen.

With reference to the optical performance of the Lick telescope, it is only necessary to refer to the catalogue of new stars. A glance at this list will make it apparent to any observer that not only is this instrument the most powerful telescope in the world, as intended by its donor, but that in definition and all other essential requisites it is practically perfect for double star work, the severest possible test for the performance of any telescope. The micrometer, driving-clock pier and other mechanical details are equally perfect for the same purpose; and there is no excuse for the observer doing other than his best work.

CATALOGUE OF 123 NEW DOUBLE STARS DISCOVERED AT THE LICK OBSERVATORY.

β 1026. LALANDE 58.

	R. A. $0^h\ 5^m\ 48^s$		Decl. + 52° 57′			
1888.76	329°.6	0″.48	8.1	. .	8.9	4n

β 1027. D. M. (20°) 15

	R. A. $0^h\ 8^m\ 44^s$		Decl. + 20° 50′			
1888.82	186° 8	1″.54	7.2	. .	10.3	3n

LALANDE 655.

	R. A. $0^h\ 23^m\ 35^s$		Decl. + 59° 19′			
1889.53	244°.6	0″.70	5.7	. .	9.5	3n

28 Andromedæ.				
R. A. 0h 23m 47s		Decl. + 29° 5′		
1889.51	360°.1	2″.42	5.5 . . 13.5	3n
A. Oe. 534.				
R. A. 0h 29m 46s		Decl. + 57° 51′		
A and B.				
1889.59	265°.2	0″.19	9.5 . . 9.6	1n
A B and C.				
1889.60	61°.8	83″.38	. . 8.9	3n
υ′ Cassiopeæ.				
R. A. 0h 47m 53s		Decl. + 58° 19′		
1889.60	75°.2	12″.79	6 . . 13.5	3n
β 1028. γ Cassiopeæ.				
R. A. 0h 48m 50s		Decl. + 60° 1′		
1888.69	255°.9	2″.18	3 . . 11	6n
1889.53	255°.4	2″.15	. . 11.6	4n
B. A. C. 255.				
R. A. 0h 49m 33s		Decl. + 59° 43′		
1889.57	270°.2	0″.15	6.1 . . 6.8	4n
Very close pair 21′ s of γ Cassiopeæ.				
Lalande 2155.				
R. A. 1h 7m 5s		Decl. + 60° 18′		
1889.54	43°.6	0″.48	7.4 . . 7.4	3n
β 1029. ζ Piscium.				
R. A. 1h 7m 27s		Decl. + 6° 56′		
B and C.				
1888.71	248°.7	0″.93	. . 11	5n
A and B (= Σ 100)				
1888.71	63°.5	23″.72	. .	5n
ψ Cassiopeæ.				
R. A. 1h 17m 27s		Decl. + 67° 30′		
A and B.				
1889.52	41°.2	3″.19	4.5 . . 13.5	4n
C and D (= Σ 117).				
1889.52	254°.7	2″.86	9.6 . . 9.8	4n
A and C (= Σ 117).				
1889.52	107°.4	28″.01	. .	4n
A. Oe. 1510.				
R. A. 1h 19m 38s		Decl. + 59° 40′		

B and C.

1889.58 336°.3 0''.84 10.3 . . 10.3 3n

A and BC.

1889.58 265°.4 60''.29 8.2 . . 3n

This is 1^m 41^s *f*, and 3' n of δ Cassiopeæ.

44 CASSIOPEÆ.

R. A. 1^h 35^m 12^s Decl. + 59° 56'

1889.54 3°.3 1''.73 6.2 . . 12.5 3n

GROOMBRIDGE 370.

R. A. 1^h 35^m 51^s Decl. + 52° 17'

1889.60 197°.2 2''.86 7.2 . . 11.8 3n

β 1030. D. M. (21°) 413.

R. A. 3^h 3^m 11^s Decl. + 21° 17'

1888.83 164°.6 0''.58 8.4 . . 8.4 3n

β 1039. LALANDE 6084.

R. A. 3^h 10^m 59^s Decl. + 7° 13'

1889.00 209°.4 1''.87 7 . . 13 3n

β 1040. LALANDE 6591.

1888.91 337°.0 3''.54 8 . . 11.7 3n

β 1041. W² III, 793, 798.

R. A. 3^h 37^m 9^s Decl. + 27° 26'

A and B.

1888.91 39°.9 123''.57 7 . . 7 3n

B and C.

1889.91 347°.8 7''.87 . . 12.8 3n

The wide pair is O Σ (app.) 38.

PLEIADES.

R. A. 3^h 41^m 26^s Decl. + 23° 49'

1889.59 59°.3 0''.33 9.2 . . 10 2n

This is D.M. (23°) 554, and is 1^m 4^s *f*, and 4'.3 *n* of Alcyone.

PLEIADES.

R. A. 3^h 42^m 58^s Decl. + 23° 51'

1889.59 51°.7 0''.40 11.5 . . 11.5 1n

Too faint to be found in any Star Catalogue. Place from the Paris map of the Pleiades. It is 55^s *f*, and 4'.6 *n* of 28 Tauri.

β 1042. LALANDE 2372.

R. A. 3^h 52^m 36^s Decl. — 3° 0'

A and B.

1888.92 93°.3 55''.93 7.5 . . 3n

B and C.

1888.92 35°.1 1''.09 8.7 . . 9.5 4n

β 1031. α TAURI.

R. A. 4h 29m 2s Decl. + 16° 16′

A and B (= β 550).

1888.82 109°.5 80″.90 1 . . 14 2n

A and C (= Σ 2 App. II).

1888.81 84°.9 116″.91 . . 3n

C and D.

1888.81 281°.1 2″.34 9 . . 12 3n

β 1043. 8 CAMELOPARDI.

R. A. 4h 30m 28s Decl. + 52° 50′

1888.92 297°.3 3″.92 5 . . 12 3n

β 1044. D. M. (16°) 637

R. A. 4h 33m 0s Decl. + 16° 16′

1888.91 218°.5 1″.03 9 . . 11 3n

This follows α Tauri 3m 58s, and is 0′.5 *n*

β 1045. 99 TAURI.

R. A. 4h 50m 32s Decl. + 23° 46′

1889.09 6°.2 6″.30 6 . . 12.3 3n

β 1046. 9 AURIGÆ.

R. A. 4h 56m 59s Decl. + 51° 26′

A and B.

1888.92 93°.8 6″.29 5.5 . . 12.7 3n

A and C (= *h*. VI. 35)

1888.92 60°.8 89″.92 . . 9 2n

β 1047. AURIGÆ 47.

R. A. 5h 2m 13s Decl. + 27° 53′

B and C.

1889.09 75°.3 0″.44 8.7 . . 9.2 3n

A and BC (Σ = 645)

1889.09 26°.6 11″.69 7.2 . . 3n

β 1048. LALANDE 10437.

R. A. 5h 26m 37s Decl. — 1° 41′

1889.13 358°.2 2″.20 6.2 . . 10.7 3n

β 1049.

R. A. 5h 27m 3s Decl. — 1° 48′

C and D.

1888.91 296°.1 0″.76 8.7 . . 9.7 4n

A and B (= Σ 734).

1888.91 355°.2 1.61 7 . . 8 4n

A and C ($=\Sigma$ 734).

1888.91	242°.8	29″.42		

β 1050. BOND 974.

R. A. 5^h 30^m 55^s Decl. — 5° 33′

1889.03	283°.6	0″.67	10.5 . . 11.7	3n

In the nebula of Orion.

β 1051. BOND 1096.

R. A. 5^h 32^m 1^s Decl. — 4° 57′

1889.09	24°.7	0″.75	10.1 . . 10.7	3n

In the nebula of Orion.

β 1032. σ ORIONIS.

R. A. 5^h 32^m 43^s Decl. — 2° 40′

A and B.

1888.81	357°.0	0″.26	4 . . 6	4n

A B and C (Σ 762).

1888.84	237°.1	11″.23	. .	3n

A B and D (Σ 762).

1888.84	83°.3	12″.84	. .	3n

A B and E (Σ 762).

1888.85	60°.5	41″.18	. .	1n

β 1052. LALANDE 10776.

R. A. 5^h 35^m 39^s Decl. — 2° 57′

1889.14	189°.1	0″.66	7.2 . . 8.2	3n

β 1053. AURIGÆ 146.

R. A. 5^h 45^m 18^s Decl. + 37° 19′

1888.92	283°.2	0″.43	7.5 . . 9.5	

β 1054. 136 TAURI.

R. A. 5^h 45^m 47^s Decl. + 27° 35′

1889.08	232°.2	15″.00	6 . . 12	3n

β 1055. B. A. C. 1899.

R. A. 5^h 51^m 32^s Decl. + 44° 35′

A and B.

1888.92	332°.9	1″.61	6.7 . . 11.5	3n

A and C ($=$ H. VI.91).

1888.92	329°.7	33″.35	. . 9.2	3n

β 1056. μ ORIONIS.

R. A. 5^h 55^m 47^s Decl. + 9° 39′

1889.11	272°.5	16″.80	4 . . 14	3n

β 1057. AURIGÆ 133.

R. A. $5^h\ 58^m\ 42^s$ Decl. + 29° 32′

1889.10	209°.5	9″.98	6.3	. .	11.2	3n

β 1058. 4 GEMINORUM.

R. A. $6^h\ 3^m\ 13^s$ Decl. + 23° 1′

1889.13	104°.3	0″.41	7.2	. .	7.5	2n

β 1059. μ GEMINORUM.

R. A. $6^h\ 15^m\ 42^s$ Decl. + 22° 34′

B and C.

1889.10	266°.7	0″.80	9.8	. .	10.7	3n

A and B C.

1889.10	141°.0	122″.49		. .	8	3n

β 1060. LALANDE 13491.

R. A. $6^h\ 52^m\ 38^s$ Decl. + 3° 46′

1889.15	58°.3	3″.01	7	. .	12	2n

β 1061. χ ARGUS.

R. A. $7^h\ 33^m\ 55^s$ Decl. — 26° 32′

B and C.

1889.12	229°.3	6″.46	13.8	. .		3n

A and B (= H. III. 27).

1889.12	318°.5	9″.98	4.1	. .	4.1	3n

β 1062. 32 GEMINORUM.

R. A. $7^h\ 41^m\ 23^s$ Decl. + 23° 26′

1889.10	32°.3	4″.06	6	. .	12.5	3n

β 1063. ξ ARGUS.

R. A. $7^h\ 44^m\ 15^s$ Decl. — 24° 34′

1889.12	188°.7	4″.63	3.5	. .	14.8	3n

β 1064. 19 ARGUS.

R. A. $8^h\ 5^m\ 39^s$ Decl. — 12° 34′

A and B.

1889.08	244°.9	1″.84	6	. .	12.5	4n

A and C (= H. IV. 26).

1889.08	255°.3	70″.68		. .	9	3n

β 1065. β CANCRI.

R. A. $8^h\ 10^m\ 0^s$ Decl. + 9° 33′

1889.11	294°.7	29″.14	3.5	. .	14	3n

β 1066. LALANDE 16489.

R. A. $8^h\ 18^m\ 31^s$ Decl. + 9° 49′

1889.12	187°.7	2″.25	6.8	. .	13.2	3n

β 1067. *o* URSÆ MAJORIS.

R. A. 8^h 20^m 17^s Decl. $+ 61° 7'$

1889.22	191.4	7″.01	3½	. .	15.2	3n

β 1068. LALANDE 17381.

R. A. 8^h 48^m 1^s Decl. $+ 9° 19'$

A and B.

1889.19	189°.9	0″.45	7.7	. .	8.8	3n

A B and C.

1889.14	313°.0	17″.80		. .	12.8	2n

β 1070. D. M. (26°) 1940.

R. A. 9^h 17^m 13^s Decl. $+ 26° 46'$

1889.13	71°.8	0″.50	9.1	. .	9.2	3n

Near χ Leonis, 27^s f, and 4′n.

β 1071. θ URSÆ MAJORIS.

R. A. 9^h 25^m 50^s Decl. $+ 52° 11'$

1889.23	74°.9	5″.09	3	. .	13.7	3n

β 1072.

R. A. 9^h 58^m 20^s Decl. $— 17° 31'$

A and B.

1889.13	42°.6	10″.90		. .	12.3	3n

A and C (= Sh. 110)

1889.13	273°.2	21″.23	6.9	. .	7.1	3n

β 1073. LALANDE 20428.

R. A. 10^h 26^m 26^s Decl. $— 5° 27'$

1889.29	46°.9	8″.02	7	. .	11.5	3n

β 1074. LALANDE 20458.

R. A. 10^h 28^m 20^s Decl. $+ 46° 26'$

1889.27	208°.4	2″.10	6.4	. .	11.2	3n

β 1075. φ^3 HYDRÆ.

R. A. 10^h 30^m 25^s Decl. $— 15° 43'$

1889.14	277°.1	8″.08	6	. .	13	3n

β 1076. 55 LEONIS.

R. A. 10^h 49^m 32^s Decl. $+ 1° 28'$

1889.28	49°.7	0″.99	5.8	. .	10.3	3n

β 1077. α URSÆ MAJORIS.

R. A. 10^h 56^m 19^s Decl. $+ 62° 24'$

1889.19	326°.1	0″.91	2	. .	11.1	4n

β 1078. CRATERIS 79.

R. A. 11^h 33^m 46^s Decl. $— 13° 48'$

1889.30	49°.3	8″.22	6.3	. .	12.2	3n

β 1079. LALANDE 22586.

R. A. $11^h\ 54^m\ 34^s$ Decl. $-21°\ 7'$

1889.30	147°.9	11″.69	6.2	. .	13.3	3n

β 1080. 17 COMÆ.

R. A. $12^h\ 22^m\ 55^s$ Decl. $+26°\ 35'$

B and C.

1889.11	156°.8	1″.79		. .	13.7	3n

A and B (= Σ 21 App. I).

1889.10	250°.3	145″.05		. .		2n

β 1081. 37 COMÆ.

R. A. $12^h\ 54^m\ 32^s$ Decl. $+31°\ 26'$

1889.13	351°.3	5″.15	4.5	. .	13.8	3n

β 1082. 78 URSÆ MAJORIS.

R. A. $12^h\ 55^m\ 35^s$ Decl. $+57°\ 1'$

1889.17	74°.6	1″.50	6	. .	9.6	6n

β 1083. P. XII. 268.

R. A. $13^h\ 0^m\ 27^s$ Decl. $+29°\ 40'$

B and C.

1889.11	237°.3	0″.49	11.5	. .	11.7	3n

A and BC (= h 2638)

1889.11	219°.9	6″.23	6.5	. .		3n

β 1084. W[1] XIII. 235.

R. A. $13^h\ 15^m\ 58^s$ Decl. $-4°\ 2'$

1889.31	89°.8	2″.69	7.1	. .	12.7	3n

A. OE$_2$. 12884.

R. A. $13^h\ 20^m\ 36^s$ Decl. $-21°\ 44'$

1889.37	133°.8	1″.17	8.5	. .	8.5	4n

B. A. C. 4631.

R. A. $13^h\ 46^m\ 32^s$ Decl. $-35°\ 4'$

A and B.

1889.38	84°.0	1″.28	6	. .	6	3n

A and C.

1889.38	168°.2	27″.52		. .	12	1n

A and D (= H. V.124).

1889.38	359°.0	65″.21		. .	8.5	2n

D.M. (5°) 2846.

R. A. $14^h\ 8^m\ 18^s$ Decl. $+5°\ 14'$

A and B.

1889.39	321°.9	1″.78		. .	13.7	3n

A and C.

1889.39	356°.3	58″.04	9	. .	9	3n

TAYLOR, 6655.

R. A. 14^h 12^m 29^s Decl. — 36° 18′

1889.39 130°.7 3″.95 7.0 . . 12.8 3n

P. XIV. 69.

R. A. 14^h 17^m 29^s Decl. + 9° 0′

B and C.

1889.40 135°.3 0″.19 8.4 . . 8.4 3n

A and BC (= Σ 1835).

1889.40 189.6 6″.36 5.4 . . 3n

LACAILLE, 5988.

R. A. 14^h 26^m 3^s Decl. — 30° 11′

1889.41 7°.6 2″.44 6.3 . . 11.1 6n

B. A. C. 4886.

R. A. 14^h 41^m 21^s Decl. + 2° 32′

1889.40 137°.1 4″.54 6.2 . . 11 8 3n

β 1085. TAYLOR 6986.

R. A. 14^h 52^m 34^s Decl. — 4° 30′

1889.30 19°.5 9″.34 6 . . 13.2 3n

β 1086. 47 BOOTIS.

R. A. 15^h 1^m 27^s Decl. + 48° 37′

1889.21 256°.6 6″.03 5.5 . . 13.2 3n

B. A. C. 5090.

R. A. 15^h 21^m 42^s Decl. — 28° 27′

A and B.

1889.38 325°.7 0″.65 7 . . 7.3 3n

A B and C (= h 4774).

1889.38 5°.8 9″.21 . . 9.8 3n

β 1087. τ CORONÆ BOREALIS.

R. A. 16^h 4^m 35^s Decl. + 36° 46′

1889.21 169°.1 3″.11 5.5 . . 13.8 3n

LALANDE 29840.

R. A. 16^h 18^m 3^s Decl. — 23° 11′

1889.39 26°.3 0″.90 8.1 . . 9.2 4n

β 1088. μ DRACONIS.

R. A. 17^h 2^m 51^s Decl. + 54° 38′

B and C.

1889.27 190°.9 12″.25 . . 13 3n

A and B (= Σ 2130).

1889.27 159°.4 2″.40 5.5 . . 5.6 4n

η OPHIUCHI.

R. A. 17^h 3^m 30^s Decl. — 15° 34′

1889.39 274°.7 0″.35 3.4 . . 3.9 4n

B. A. C. 5820.

R. A. $17^h\ 9^m\ 40^s$ Decl. $-30°\ 2'$

1889.40	355°.8	0″.75	7.0	. .	7.6	3n

B. A. C. 5896.

R. A. $17^h\ 21^m\ 14^s$ Decl. $-25°\ 24'$

1889.14	100°.0	0″.93	7	. .	7	3n

β 1089. Yarnall 7270.

R. A. $17^h\ 23^m\ 22^s$ Decl. $-5°\ 49'$

1888.64	5°.2	0″.95	6.8	. .	11	3n

β 1090. β Draconis.

R. A. $17^h\ 27^m\ 43^s$ Decl. $+52°\ 23'$

1889.26	13°.4	3″.97	3	. .	14	4n

D. M. (12°) 3264.

R. A. $17^h\ 31^m\ 52^s$ Decl. $+12°\ 37'$

1889.14	240°.1	0″.71	8.5	. .	9.0	3n

Cord. Gen. Cat. 24248.

R. A. $17^h\ 44^m\ 38^s$ Decl. $-28°\ 27'$

B and C.

1889.39	175°.2	1″.81	10.4	. .	10.9	3n

A and B C.

1889.39	9°.6	6″.46	8.7	. .		3n

Wide pair noted by Howe. Both stars in Argentine General Catalogue.

Cord. Gen. Cat. 24262.

R. A. $17^h\ 45^m\ 20^s$ Decl. $-34°\ 42'$

1889.48	212°.8	0″.58	7.4	. .	7.8	4n

67 Ophiuchi.

R. A. $17^h\ 54^m\ 38^s$ Decl. $+2°\ 56'$

A and B.

1889.39	195°.6	6″.79	5	. .	14.8	3n

A and C (= Sh 255).

1889.40	143°.6	54″.54		. .		2n

C and D.

1889.40	129°.6	8″.40	8.8	. .	11.5	2n

68 Ophiuchi.

R. A. $17^h\ 55^m\ 40^s$ Decl. $+1°\ 19'$

1889.39	14°.9	1″.01	5.1	. .	9.9	5n

Y. 7599.

R. A. $17^h\ 56^m\ 54^s$ Decl. $-24°\ 15'$

A and B.

1889.40	55°.6	0″.63	8.7	. .	9.5	4n

A and C (= h 5009).

1889.40	23°.3	4″.05		. .	9.6	4n

GROOMBRIDGE 2500.

R. A. $17^h\ 58^m\ 59^s$ Decl. + 44° 18′

1889.53 144°.7 0″.80 7.8 . . 9.7 3n

β 1091. LALANDE 33592.

R. A. $18^h\ 8^m\ 35^s$ Decl. + 38° 34′

1888.78 38°.1 0″.53 8.6 . . 8.6 2n

B. A. C. 6285.

R. A. $18^h\ 23^m\ 12^s$ Decl. — 33° 4′

1889.42 198°.6 3″.17 6.1 . . 11.5 3n

β 1033. ν^2 SAGITTARII.

R. A. $18^h\ 47^m\ 51^s$ Decl — 22° 49′

1888.68 104°.0 1″.37 5.5 . . 11 1n

GROOMBRIDGE 2829.

R. A. $19^h\ 18^m\ 51^s$ Decl. + 52° 9′

1889.48 344°.3 0″.34 6.3 . . 6.8 3n

9 VULPECULÆ.

R. A. $19^h\ 29^m\ 18^s$ Decl. + 19° 23′

1889.48 31°.3 9″.53 5.5 . . 14 3n

θ CYGNI.

R. A. $19^h\ 33^m\ 13^s$ Decl. + 49° 56′

1889.37 43°.9 3″.62 5 . . 14.3 3n

D. M. (26°) 3640.

R. A. $19^h\ 38^m\ 11^s$ Decl. + 26° 39′

1889.56 227°.3 0″.49 8.3 . . 8.7 3n

LALANDE 38224.

R. A. $19^h\ 54^m\ 56^s$ Decl. + 31° 30′

1889.56 338°.6 0″.87 6.8 . . 9.5 3n

RUMKER 8289.

R. A. $20^h\ 19^m\ 29^s$ Decl. + 63° 36′

1889.48 80°.6 4″.32 5.8 . . 12 7 3n

Not found in any other Star Catalogue except the D. M.

LALANDE 39561.

R. A. $20^h\ 25^m\ 10^s$ Decl. + 45° 20′

1889.53 338°.3 1″.53 8.3 . . 10.7 4n

LALANDE 39698.

R. A. $20^h\ 28^m\ 6^s$ Decl. + 49° 8′

1889.54 206°.6 0″.35 8.1 . . 9.7 3n

β 1034. 7 AQUARII.

R. A. $20^h\ 50^m\ 25^s$ Decl. — 10° 9′

1888.68 165°.0 2″.09 6 . . 11.7 5n

B. A. C. 7278.

R. A. $20^h\ 52^m\ 36^s$ Decl. $+\ 50°\ 16'$

1889.44 344°.3 6''.88 6 . . 13.7 3n

Lalande 40856.

R. A. $20^h\ 58^m\ 34^s$ Decl. $+\ 45°\ 22'$

1889.44 188°.7 0''.29 7.2 . . 8.5 3n

Radcliffe 5088.

R. A. $20^h\ 58^m\ 39^s$ Decl. $+\ 56°\ 36'$

1889.37 138°.6 1''.86 6 . . 12.5 3n

Radcliffe 5183.

R. A. $21^h\ 14^m\ 1^s$ Decl. $+\ 58°\ 6'$

1889.56 276°.5 3''.89 6.7 . . 12.3 3n

β 1035. B. A. C. 7422.

R. A. $21^h\ 17^m\ 16^s$ Decl. $-\ 26°\ 4'$

1888.74 198°.7 1''.05 8 . . 10.7 3n

A. Oe. 22270.

R. A. $21^h\ 22^m\ 7^s$ Decl. $+\ 57°\ 43'$

1889.58 165°.9 2''.72 7.7 . . 13.2 3n

D. M. (56°) 2579.

R. A. $21^h\ 25^m\ 6^s$ Decl. $+\ 56°\ 33''$

1889.59 353°.9 0''.41 8.7 . . 8.7 3n

β 1036. Yarnall 9529.

R. A. $21^h\ 40^m\ 59^s$ Decl. $-\ 17°\ 51'$

1888 74 205°.9 4''.58 8 . . 11 3n

β 1092. Radcliffe 5777.

R. A. $22^h\ 33^m\ 3^s$ Decl. $+\ 72°\ 15'$

A and B.

1889.30 237°.1 0''.32 7.5 . . 7.5 2n

A B and D (=H. V.94).

1889.31 137.4 42''.17 7.2 . . 7.2 3n

A B and C.

1889.31 264°.0 29''.19 . . 12.2 3n

P. xxi. 248.

R. A. $21^h\ 35^m\ 14^s$ Decl. $+\ 56°\ 57'$

A and B.

1889.61 323°.5 1''.55 6 . . 13.7 2n

A and C (= Σ 2816).

1889.61 120°.4 11''.86 . . 7.3 3n

A and D (= Σ 2816).

1889.61 339°.5 19''.94 . . 7.3 3n

η Pegasi.

R. A. $22^h\ 37^m\ 23^s$ — Decl. $+\ 29^\circ\ 36'$

B and C.

1889.53	83°.3	0″.29	10.1	. .	10.1	4n

A and B C (=H. VI.21).

1889.53	339°.0	90″.38		. .		4n

β 1037. D. M. (12°) 4888.

R. A. $22^h\ 41^m\ 56^s$ — Decl. $+\ 12^\circ\ 22'$

1888.81	224°.4	0″.66	8.7	. .	10.8	3n

A. OE. 24690.

R. A. $22^h\ 42^m\ 45^s$ — Decl. $+\ 57^\circ\ 55'$

A and B.

1889.59	153°.0	1″.03	8.2	. .	11.0	3n

A and C.

1889.59	179°.5	21″.99		. .	9.5	3n

W² XXII. 971.

R. A. $22^h\ 42^m\ 48^s$ — Decl. $+\ 30^\circ\ 28''$

1889.55	335°.3	0″.23	7.2	. .	8.2	3n

2 ANDROMEDÆ.

R. A. $22^h\ 57^m\ 5^s$ — Decl. $+\ 42^\circ\ 7'$

1889.54	317°.8	0″.28	5	. .	8.7	3n

GROOMBRIDGE 4070.

R. A. $23^h\ 22^m\ 12^s$ — Decl. $+\ 64^\circ\ 58$

1889.60	73°.9	2″.13	7.1	. .	13	3n

D. M. (57°) 2746.

R. A. $23^h\ 24^m\ 11^s$ — Decl. $+\ 58^\circ\ 1'$

1889.58	309°.1	0″.52	9.4	. .	9.8	

This pair is 231″ from $O\Sigma$ 496 in the direction of 207°.6

A. OE. 25672.

R. A. $23^h\ 24^m\ 46^s$ — Decl. $+\ 64^\circ\ 24'$

1889.60	44°.0	0″.61	8.7	. .	9.0	3n

ANONYMOUS.

R. A. $23^h\ 25^m\ 6^s$ — Decl. $+\ 57^\circ\ 43'$

1889.59	293°.7	0″.64	9.7	. .	9.7	3n

This pair is 116″.88 from Σ 3022 in the direction of 189°.7 Not in any Star Catalogue.

GROOMBRIDGE 4142.

R. A. $23^h\ 42^m\ 17^s$ — Decl. $+\ 63^\circ\ 9'$

B and C.

1889.60	102°.4	0″.64	9.2	. .	9.2	3n

A and B C.

1889.60	136°.8	74″.28	7.5	. .		3n

β 1038. D. M. (41°) 4881.

	R. A. $23^h\ 45^m\ 31^s$		Decl. + 41° 25′				
1888.78	157°.6	0″.60	8.3	. .	8.3	3n

D. M. (73°) 1068.

	R. A. $23^h\ 55^m\ 12^s$		Decl. + 74° 8′			
1889.51	310°.1	0″.98	8	. .	8.2	3n

MICROMETRICAL MEASURES OF KNOWN DOUBLE STARS.

β Cassiopeæ.

	R. A. $0^h\ 42^m\ 43^s$		Decl. + 58° 29′			
1889.59	189°.2	22″.63	2.5	. .	13.7	3n

This faint star was first noted, I think, by Mr. Alvan G. Clark.

β 253.

	R. A. $0^h\ 4^m\ 5^s$		Decl. + 57° 51′			
1889.28	50°.8	0″.65	8.3	. .	8.8	3n

β 485.

	R. A. $0^h\ 4^m\ 30^s$		Decl. + 58° 6′			
1889.55	307°.4	0″.44	8.5	. .	8.6	3n

β 486. Ceti 33.

	R. A. $0^h\ 8^m\ 19^s$		Decl. — 8° 27′			
1888.91	5°.3	3″.09	5	. .	11	1n

Σ 13.

	R. A. $0^h\ 9^m\ 25^s$		Decl. + 76° 17′			
1889.41	91°.7	0″.81	6.2	. .	6.3	4n

β 392. B. A. C. 46.

	R. A. $0^h\ 10^m\ 31^s$		Decl. + 60° 52′			
1888.71	68°.2	19″.18	6.5	. .	12.3	3n

β 395. B. A. C. 160.

	R. A. $0^h\ 31^m\ 9^s$		Decl. — 25° 26′			
1888.91	112°.4	0″.98		. .		1n

β 491. δ Andromedæ.

	R. A. $0^h\ 32^m\ 54^s$		Decl. + 30° 12′			
1888.71	299°.7	27″.60	3	. .	12.5	3n

α Cassiopeæ

R. A. $0^h\ 33^m\ 42^s$ Decl. + 55° 53′

A and B.

1889.60	272°.4	17″.56	2	. .	14.5	3n

A and C.

1889.60	106°.5	39″.72		. .	14	3n

A and D (= *h* 1993).

1889.60	280°.2	63″.20		. . 9	3n

β 231. *o* Cassiopeæ.

R. A. 0^h 38^m 2^s Decl. + 47° 38′

1888.71	303°.5	32″.68		. . 11.6	3n

β 492. B. A. C. 201.

R. A. 0^h 38^m 28^s Decl. + 54° 34′

1889.55	152°.7	2″.11	5.7	. . 11.3	3n

β 1.

R. A. 0^h 45^m 45^s Decl. + 55° 58′

A and B.

1889.55	82°.6	1″.45	8.2	. . 9.8	3n

A and C.

1889.55	134°.2	3″.82		. . 8.7	3n

A and D.

1889.55	198°.7	8″.97		. . 8.7	3n

A and E.

1889.55	333°.1	15″.84		. . 12.5	3n

β 734.

R. A. 0^h 46^m 47^s Decl. — 24° 39′

1888.84	346°.9	10″.83	7	. . 10	2n

β 396. B. A. C. 282.

R. A. 0^h 56^m 13^s Decl. + 60° 26′

1888.72	66°.8	1″.25	6.3	. . 9.3	4n
1889.53	66°.4	1″.28	6.0	. . 10	3n

β 235.

R. A. 1^h 3^m 27^s Decl. + 50° 22′

1889.53	86°.1	0″.79	7.2	. . 7.8	3n

β 258.

R. A. 1^h 5^m 29^s Decl. + 61° 4′

1889.57	268°.2	0″.99	6.3	. . 9.7	3n

Polaris.

R. A. 1^h 13^m 45^s Decl. + 88° 40′

1889.29. Both stars single with 36-inch, and no near companion seen.

β 999. *ω* Andromedæ.

R. A. 1^h 20^m 27^s Decl. + 44° 47′

A and B.

1888.70	95°.4	2″.64	6	. . 11.8	3n

A and C.

1888.75	110°.8	132″.49		. .	3n

C and D.

1888.75	137°.9	4″.96	10.2	. .	10.2	3n

β 506. η PISCIUM.

R. A. 1^h 25^m 4^s Decl. + 14° 44′

1888.73	16°.5	1″.10	4	. .	10	3n

β 305. PERSEI 58.

R. A. 1^h 30^m 52^s Decl. + 37° 13′

1888.71	205°.5	20″.78	7	. .	10.7	2n

β 513 48 CASSIOPEÆ.

R. A. 1^h 52^m 7^s Decl. + 70° 19′

1888.70	298°.1	0″.83	5	. .	6.8	4n
1889.52	304°.4	0″.76	5	. .	9	3n

Binary in rapid motion.

β 785. 49 CASSIOPEÆ.

R. A. 1^h 54^m 4^s Decl. + 75° 32′

1889.52	243°.7	5″.40	5.1	. .	13.2	3n

OΣ 38. γ ANDROMEDÆ.

R. A. 1^h 56^m 32^s Decl. + 41° 45′

1888.600. Only a slight elongation in the direction of 120° with 2700 on the 36-inch.

1889.515	98°.2	0″.09		. .		1n

Σ 279.

R. A. 2^h 28^m 15^s Decl. + 36° 47′

1888.71	70.8	17″.73	6.9	. .	10.7	2n

β 524. 20 PERSEI.

R. A. 2^h 46^m 9^s Decl. + 37° 51′

A and B.

1888.68	83°.9	0″.23	6	. .	6	1n
1889.59	291°.3	0″.17	5.5	. .	6	1n

A B and C (= Σ 318).

1888.68	236°.7	13″.80		. .	9	1n

A. C. 2. 95 CETI.

R. A. 3^h 12^m 12^s Decl. — 1° 22′

1888.77	112°.8	0″.45	6	. .	8.5	2n

Σ 412. 7 TAURI.

R. A. 3^h 27^m 20^s Decl. 24° 4′

A and B.

A B and C.

β 535 38 PERSEI.

R. A. 3^h 36^m 47^s Decl. + 31° 54′

1888.71	59°.2	1″.09		. .		3n

β 547. 47 TAURI.

R. A. $4^h\ 7^m\ 25^s$ Decl. $+8° 58'$

1888.81	359°.7	0″.91	5.7	. .	8.3	3n

Σ 518. 40 ERIDANI.

R. A. $4^h\ 9^m\ 52^s$ Decl. $-7° 47'$

B and C.

1888.84	106°.8	2″.04		. .		3n

A and B.

1888.84	105°.5	82″.15		. .		2n

Σ 566. 2 CAMELOPARDI.

R. A. $4^h\ 30^m\ 27^s$ Decl. $+53° 14'$

A and B.

1888.92	291°.9	1″.58		. .		3n

A and C.

1888.92	209°.8	23″.66		. .	13.2	3n

β 314. LEPORIS 8.

R. A. $4^h\ 58^m\ 39^s$ Decl. $-16° 34'$

A and B.

1889.13	326°.9	1″.05	6.5	. .	8.8	3n

A and C.

1889.13	29°.0	54″.45		. .	8.2	2n

β 555. β ORIONIS.

R. A. $5^h\ 8^m\ 47^s$ Decl. $-8° 20'$

B and C.

1889.093. No certain elongation.

Σ 719.

R. A. $5^h\ 22^m\ 27^s$ Decl. $+29° 27'$

A and B.

1889.10	334°.6	1″.08	6.5	. .	9	1n

A and C.

1889.10	351°.4	15″.16		. .	8.5	1n

Σ 728. 32 ORIONIS.

R. A. $5^h\ 24^m\ 22^s$ Decl. $+5° 51'$

1889.08	179°.2	0″.38	4.7	. .	6	3n

θ ORIONIS.

R. A. $5^h\ 29^m\ 23^s$ Decl. $-5° 28'$

A and B.

1888.88	32°.3	8″.74		. .		3n

A and C.

1888.88	131°.3	12″.95		. .		3n

		D and C.				
1888.87	240°.6	13″.35		. .		3n
		D and B.				
1888.88	299°.5	19″.39		. .		3n
		B and C.				
1888.88	163°.0	16″.76		. .		3n
		A and D.				
1888.88	95°.4	21″.55		. .		3n
		A and E (Fifth Star).				
1888.88	351°.5	4″.31		. .		3n
		C and F (Sixth Star).				
1888.86	120°.9	3″.99		. .		3n
		C and G (A. G. Clark's star).				
1888.98	38°.9	7″.40		. .	16	4n
		D and G.				
1888.98	270°.5	7″.03		. .		4n
		A and H (Barnard's star).				
1889.00	178°.4	7″.94		. .	16	2n
		C and H.				
1889.02	275°.6	8″.62		. .		3n
		H^1 and H^2 (Barnard's pair).				
1889.07	274°.0	1″.32	16	. .	16.5	1n

S. 508.

R. A. $5^h\ 49^m\ 10^s$ Decl. + 13° 56′

		A and B.				
1889.11	8°.6	3″.36	7	. .	8	3n
		A and C.				
1889.11	163°.2	20″.92		. .	10.8	3n

β 1008. η Geminorum.

R. A. $6^h\ 7^m\ 38^s$ Decl. + 22° 32′

1889.14	294°.8	1″.04	3	. .	10.5	3n

A. G. C. 1. Sirius.

R. A. $6^h\ 39^m\ 53^s$ Decl. — 16° 33′

1888.97	13°.9	5″.27		. .		5n

Procyon.

R. A. $7^h\ 33^m\ 1^s$ Decl. + 5° 33′

1888.82 Carefully examined with the 36-inch. Nothing nearer than the old companion.

β 580.

R. A. $7^h\ 38^m\ 1^s$ Decl. + 28° 19′

1889.14	130°.9	1″.14	9.5	. .	12.5	1n

This is one of the distant companions to Pollux.

β 101. 9 ARGUS.

	R. A. $7^h\ 46^m\ 13^s$		Decl. — 13° 35′		
1889 08	76°.4	0″.34	5.7 . .	6.3	4n

Σ 1196. ζ CANCRI.

R. A. $8^h\ 5^m\ 20^s$ Decl. + 18° 1′

1888.29. No other component seen.

β 208.

	R. A. $8^h\ 33^m\ 54^s$		Decl. — 22° 16′		
1889.15	47°.5	1″.06	7 . .	8	2n

Σ 1273. ε HYDRÆ.

R. A. $8^h\ 40^m\ 25^s$ Decl. + 6° 52′

	A and B (Perrotin).				
1889.98	154°.4	0″.26	4 . .	6	2n
	A B and C.				
1889.08	226°.5	3″.16	. .		3n
	A B and D.				
1889.22	193°.8	19″.68	. .		2n

PERROTIN.

	R. A. $8^h\ 44^m\ 49^s$		Decl. + 8° 47′		
1889.12	350°.1	0″.95	7.9 . .	8.6	3n

χ CANCRI.

R. A. $9^h\ 1^m$ Decl. + 11° 10′

1889.13. No indication of duplicity.

β 105. χ LEONIS.

	R. A. $9^h\ 17^m\ 40^s$		Decl. + 26° 42′		
1889.13	203°.9	2″.79	4.5 . .	10.9	3n

JACOB 5.

	R. A. $9^h\ 25^m\ 26^s$		Decl. — 28° 14′		
1889.24	248°.8	1″.05	6.3 . .	7.1	3n

OΣ 521. υ URSÆ MAJORIS.

	R. A. $9^h\ 42^m\ 30^s$		Decl. + 59° 36′		
1889.18	294°.5	11″.23	5 . .	12.5	3n

A. C. 5. 8 SEXTANTIS.

	R. A. $9^h\ 46^m\ 34^s$		Decl. — 7° 32′		
1889.17	125°.6	0″.54	5.5 . .	6	3n

Σ 1424. γ LEONIS.

	R. A. $10^h\ 13^m\ 20^s$		Decl. + 20° 27′		
1889.29	114°.6	3″.51	. .		3n

β 599. 65 LEONIS.

	R. A. $11^h\ 1^m\ 50^s$		Decl. + 2° 30′		
1889.27	88°.5	1″.78	5.6 . .	10.5	3n

β 916. Crateris 31.

	R. A. 11h 8m 13s		Decl. — 14° 47′	
1889.25	0°.2	0″.88	7.5 . . 8.3	3n

h 4478. β Hydræ.

	R. A. 11h 46m 51s		Decl. — 33° 14′	
1889.43	349°.6	1″.58	. .	3n

β 607.

	R. A. 12h 35m 2s		Decl. — 0° 48′	
1889.31	316°.3	1″.20	9 . . 10	3n

Σ 1670. γ Virginis.

R. A. 12h 35m 37s — Decl. — 0° 47′

A and B.

1889.31	153°.4	5″.72	. .	3n

A and C.

1889.30	159°.4	58″.12	. . 14.5	3n

β 609.

	R. A. 13h 4m 28s		Decl. — 4° 18′	
1889.31	349°.1	0″.91	6.8 . . 9.8	3n

β 935. 86 Virginis.

R. A. 13h 39m 33s — Decl. — 11° 49′

A and B.

1889.30	299°.6	1″.66	5.8 . . 10	3n

C and D.

1889.30	275°.9	2″.24	10.5 . . 11.2	3n

A and C (= Σ 1780 rej.)

1889.30	164°.6	27″.17	. .	3n

β 413.

	R. A. 13h 42m 15s		Decl. — 27° 46′	
1889.39	109°.5	77″.66	7.7 . . 9.2	3n

β 343. Centauri 219.

	R. A. 13h 45m 8s		Decl. — 31° 1′	
1889.37	129°.7	1″.70	6.2 . . 7.1	4n

β 614.

	R. A. 13h 48m 2s		Decl. + 10° 44′	
1889.40	271°.1	0″.44	7.8 . . 11.2	3n

Swift.

	R. A. 13h 57m 40s		Decl. + 46° 55′	
1889.39	6°.7	2″.44	9 . . 9	2n

β 940. 52 Hydræ.

	R. A. 14h 21m 9s		Decl. — 28° 57′	
1889.38	278°.7	4″.27	. . 10.8	3n

β 414. Centauri 315.

R. A. $14^h\ 34^m\ 42^s$ Decl. — 30° 25′

1889.43	345°.6	1″.01	6.5	. .	7.9	3n

Holden. 5 Libræ.

R. A. $14^h\ 39^m\ 21^s$ Decl. — 14° 57′

1889.38	249°.2	2″.79	6.2	. .	11.3	3n

β 106. μ Libræ.

R. A. $14^h\ 42^m\ 45^s$ Decl. — 13° 39′

		A and B.				
1889.38	340°.6	1″.61	5	. .	6	3n
		A and C.				
1889.38	283°.7	18″.33		. .	14.5	3n
		A and D.				
1889.38	185°.5	25″.96		. .	13.9	3n
		A and E.				
1889.38	232°.5	27″.19		. .	12.8	3n

β 447.

R. A. $14^h\ 47^m\ 18^s$ Decl. — 32° 49′

		A and B.				
1889.45	320°.5	13″.01	6.5	. .	10.5	3n
		A and C.				
1889.45	243°.1	58″.46		. .	9.3	3n

β 239. 59 Hydræ.

R. A. $14^h\ 51^m\ 23^s$ Decl. — 27° 10′

1889.44	311°.4	0″.86	5.8	. .	5.9	3n

β 348. 2 Serpentis.

R. A. $14^h\ 55^m\ 40^s$ Decl. + 0° 20′

1889.31	119°.0	0″.76	6	. .	6.7	2n

Σ 1926.

R. A. $15^h\ 10^m\ 23^s$ Decl. + 38° 45′

1889.35	257°.7	1″.10	7.7	. .	9.2	3n

β 943.

R. A. $15^h\ 12^m\ 16^s$ Decl. + 1° 23′

1889.30	92°.7	2″.63	6.2	. .	12.3	3n

β 32. 6 Serpentis.

R. A. $15^h\ 14^m\ 54^s$ Decl. + 1° 9′

1889.30	17°.9	2″.44	5.8	. .	10	3n

β 121. B. A. C. 5163.

R. A. $15^h\ 32^m\ 20^s$ Decl. — 27° 15′

1889.47	277°.5	1″.45	8.2	. .	8.2	3n

β 947. β Scorpii.

R. A. 15^h 58^m 28^s Decl. — 19° 29′

A and B.

1889.41	93°.9	0″.94		. .	10.8	5n

β 811.

R. A. 16^h 0^m 26^s Decl. + 22° 18′

1889.49	220°.7	8″.70	7.8	. .	10.8	3n

β 120. ν Scorpii.

R. A. 16^h 5^m 1^s Decl. — 19° 9′

1889.44	1°.2	0″.80		. .		3n

Sh. 228. ρ Ophiuchi.

R. A. 16^h 18^m 23^s Decl. — 23° 10′

A and B.

1889.39	355°.0	3″.41	5.5	. .	5.8	3n

A and C.

1889.39	359°.8	151.15″		. .	8	2n

A and D.

1889.39	253°.0	156″.43		. .	8	3n

D, as a close pair, is given in the list of new doubles.

β 815.

R. A. 16^h 23^m 16^s Decl. + 43° 11′

1889.43	343°.3	7″.68	8.5	. .	10.8	3n

β 818. 32 Herculis.

R. A. 16^h 28^m 50^s Decl. + 30° 45′

1889.28	32°.9	3″.64	6	. .	13.5	3n

Kustner.

R. A. 16^h 48^m 27^s Decl. + 77° 43′

1889.21	189°.3	2″.72	7	. .	10.3	3n

Σ 2118. 20 Draconis.

R. A. 16^h 55^m 49^s Decl. + 65° 18′

1889.45	140°.7	0″.11	5.5	. .	6	3n

β 823.

R. A. 17^h 0^m 29^s Decl. + 0° 49′

1889.48	359°.8	1″.17	8.3	. .	9.5	3n

β 125.

R. A. 17^h 4^m 43^s Decl. — 26° 58′

1889.47	61°.3	1″.48	7.9	. .	10	3n

β 282.

R. A. 17^h 8^m 29^s Decl. — 14° 27′

1889.42	151°.9	4″.31	6.3	. .	11.3	3n

β 957.

R. A. $17^h\ 8^m\ 57^s$ Decl. — 10° 10′

1889.50	201°.7	0″.47	8.2	. .	8.4	3n

α HERCULIS.

R. A. $17^h\ 9^m\ 10^s$ Decl. + 14° 32′

A and C.

1888.49	335°.8	28″.54		. .	15	2n

β 416.

R. A. $17^h\ 10^m\ 47^s$ Decl. — 34° 51′

A and B.

1889.25	137°.4	1″.48	6.3	. .	7.5	4n

A B and C (= h 4935).

1889.43	128°.6	31″.08		. .	10.5	3n

SWIFT.

R. A. $17^h\ 15^m$ Decl. + 53° 47′

1889.48	132°.0	0″.57	8.9	. .	9.0	3n

β 962. 26 DRACONIS.

R. A. $17^h\ 33^m\ 44^s$ Decl. + 61° 58′

1889.42	130°.1	0″.95	4.7	. .	11	4n

A. C. 7. μ HERCULIS.

R. A. $17^h\ 41^m\ 47^s$ Decl. + 27° 48′

B and C.

1889.51	357°.9	0″.55	10	. .	10.1	4n

β 633. γ DRACONIS.

R. A. $17^h\ 53^m\ 49^s$ Decl. + 51° 30′

1889.25	151°.3	21″.10		. .	12.5	3n

Σ 2268.

R. A. $17^h\ 58^m\ 20^s$ Decl. + 25° 22′

A and B (= β 825.)

1889.47	194°.6	11″.20		. .	11.3	3n

A and C (= Σ 2268).

1889.47	211°.6	20″.00	8.5	. .	8.8	4n

Σ 2272. 70 OPHIUCHI.

R. A. $17^h\ 59^m\ 28^s$ Decl. + 2° 33′

A and B.

1889.30	348°.7	2″.16		. .		2n

A and C.

1889.30	203°.3	59″.45		. .	12.7	2n

A and D.

1889.30	43°.2	95″.17		. .	12.2	2n

$O\Sigma$ 342. 72 Ophiuchi.

R. A. 18h 1m 42s   Decl. + 9° 33′

1889.30   Large star single.

A. C. 15. 99 Herculis.

R. A. 18h 2m 28s   Decl. + 30° 33′

1889.50   281°.2   0″.65   6 . . 11.5   1n

β 759.

R. A. 18h 3m 54s   Decl. — 39° 32′

A and B.

1889.40   121°.4   1″.81   8.9 . . 9.1   3n

A and C (= h 5028.)

1889.40   147°.3   14″.92   . . 9.0   3n

β 760. η Sagittarii.

R. A. 18h 9m 31s   Decl. — 36° 48′

A and B.

1889.41   107°.0   3″.51   . . 11.4   4n

A and C.

1889.41   302°.8   93″.22   . . 10   2n

$O\Sigma$ 357.

R. A. 18h 30m 21s   Decl. + 11° 37′

1889.21   72°.8   0″.48   8.2 . . 8.2   3n

ζ Lyrae.

R. A. 18h 40m 38s   Decl. + 37° 29′

A and B (new).

1889.43   48°.7   26″.98   . . 15.7   2n

A and C (= Σ 28 App. I).

1889.43   149°.3   48″.73   . .   2n

Σ 2400.

R. A. 18h 43m 32s   Decl. + 16° 7′

A and B (Perrotin).

1889.47   189°.0   1″.61   8.2 . . 11.1   4n

A and C (Σ 2400).

1889.47   191°.7   2″.54   . . 11.0   4n

B and C.

1889.48   17°.5   0″.81   . .   2n

Σ 3130.

R. A. 18h 52m 20s   Decl. + 44° 4′

1889.46   Large star single, with all powers to 1900.

ζ Sagittarii.

R. A. 18h 55m 0s   Decl. — 30° 3′

1888.62   257°.4   0″.70   . .   6n

1889.41   255°.1   0″.81   . .   5n

Σ 2438.

R. A. $18^h 55^m 29^s$ Decl. + 58° 4′

1889.46 46°.2 0″.24 7.2 . . 7.3 3n

γ CORONAE AUSTRALIS.

R. A. $18^h 58^m 18^s$ Decl. — 37° 14′

1889.41 135°.4 1″.79 5.5 . . 5.5 4n

β 287. ζ AQUILAE.

R. A. $18^h 59^m 54^s$ Decl. + 13° 41′

1889.43 57°.3 5″.63 . . 13 3n

β 654. 52 SAGITTARII.

R. A. $19^h 29^m 24^s$ Decl. — 25° 10′

1889.42 159°.1 3″.00 5.1 . . 11.5 4n

β 761.

R. A. $19^h 31^m 45^s$ Decl. — 39° 42′

1889.42 198°.2 2″.45 7.7 . . 10.2 3n

KUSTNER.

R. A. $19^h 35^m 38^s$ Decl. + 71° 20′

1889.27 271°.1 1″.44 7.2 . . 9.2 3n

OΣ 380. χ AQUILAE.

R. A. $19^h 36^m 55^s$ Decl. + 11° 38′

1889.59 Certainly no third star.

β 658. B. A. C. 6762.

R. A. $19^h 39^m 1^s$ Decl. + 26° 50′

1889.56 299°.9 0″.50 6.7 . . 9.7 3n

A. C. 9 ζ SAGITTAE.

R. A. $19^h 43^m 39^s$ Decl. + 18° 51′

1889.57 5°.0 0″.12 4 . . 4.5 2n

β 980. η CYGNI.

R. A. $19^h 51^m 48^s$ Decl. + 34° 46′

A and B.

1889.51 210°.4 7″.21 4 . . 13 4n

A and C.

1889.51 326°.2 46″.08 . . 11 2n

A and D.

1889.51 169°.1 49″.82 . . 10.7 2n

Ho. 121.

R. A. $20^h 7^m 25^s$ Decl. + 34° 7′

A and B.

1889.43 17°.5 22″.42 7.3 . . 10.8 3n

A and C.

1889.43 14°.5 41″.56 . . 12 2n

α^2 Capricorni.

R. A. $20^h\ 11^m\ 24^s$ Decl. — $12^\circ\ 55'$

B and C (A. G. Clark).

1889.48	239°.0	1″.19	11.3	. .	11.5	3n

A and B (= h 608).

1889.48	146°.8	7″.75		. .		3n

Barnard. β^1 Capricorni.

R. A. $20^h\ 14^m\ 2^s$ Decl. — $15^\circ\ 10'$

1888.66	105°.9	0″.84		. .		4n

β 481.

R. A. $20^h\ 15^m\ 25^s$ Decl. + $35^\circ\ 58'$

1889.53	88°.2	0″.66	8.6	. .	8.6	4n

β 763. χ^2 Sagittarii.

R. A. $20^h\ 15^m\ 45^s$ Decl. — $42^\circ\ 48'$

1889.47	211°.2	1″.336		. .	8.9	4n

β 151. β Delphini.

R. A. $20^h\ 31^m\ 55^s$ Decl. + $14^\circ\ 11'$

A and B.

1888.65	310°.1	0″.29		. .		7n
1889.50	314°.2	0″.31		. .		5n

A and C.

1888.82	115°.7	26″.77		. .		2n

A and D (= Σ 2704).

1888.82	333°.2	36″.35		. .		2n

Ho. 137.

R. A. $20^h\ 53^m\ 37^s$ Decl. + $29^\circ\ 23'$

1888.75	273°.5	0″.88	7	. .	10	2n

β 675. 51 Cygni.

R. A. $20^h\ 38^m\ 31^s$ Decl. + $49^\circ\ 54'$

1889.45	101″.5	2″.99	5	. .	13.2	3n

61 Cygni.

R. A. $21^h\ 1^m\ 14^s$ Decl. + $38^\circ\ 8'$

1889.48 Both stars single.

β 679.

R. A. $21^h\ 1^m\ 25^s$ Decl. + $48^\circ\ 12'$

1889.45	65°.6	0″.52	10	. .	10	3n

Ho. 149.

R. A. $21^h\ 1^m\ 26^s$ Decl. — $12^\circ\ 10'$

1888.72	326°.8	0″.90	8.2	. .	8.7	4n

Knott. γ Equulei.

R. A. $21^h\ 4^m\ 30^s$ Decl. + $9^\circ\ 39'$

A and B.

1888.82	275°.4	2″.14		. .	3n

A and C.

1888.82	9°.2	43″.33		. .	3n

β 159.

R. A. 21h 6m 21s Decl. + 47° 12′

A and B.

1889.53	316°.7	1″.28	7.1	. . 9.7	3n

A and C.

1889.53	189°.4	134″.16		. . 7.3	2n

Ho. 152.

R. A. 21h 7m 20s Decl. + 27° 51′

1888.75	328°.9	0″.70	8.6	. . 9.2	2n

OΣ 535. δ Equulei.

R. A. 21h 8m 38s Decl. + 9° 31′

1888.69	189°.9	0″.25		. .	4n
1889.51	343°.2	0″.10 ±		. .	1n

A. G. Clark. τ Cygni.

R. A. 21h 10m 0s Decl. + 37° 32′

A and B.

1889.49	36°.5	0″.50		. . 10	4n

A and C.

1889.32	246°.7	19″.33		. . 13.2	2n

β 766. θ² Microscop.

R. A. 21h 16m 49s Decl. — 41° 31′

1889.43	307°.1	1″.06	5	. . 7	1n

β 989. κ Pegasi.

R. A. 21h 39m 12s Decl. + 25° 6′

A and B.

1888.78	274°.7	0″.23		. .	3n
1889.51	262°.3	0″.14	4.3	. . 5	4n

A B and C (= Σ 2824).

1888.82	300°.7	12″.22		. .	2n

β 690. μ Cephei.

R. A. 21h 39m 50s Decl. + 58° 14′

1889.52	259°.6	19″.58	6	. . 13.2	3n

β 276. η Piscis Aust.

R. A. 21h 53m 57s Decl. — 29° 2′

1888.78	118°.5	1″.61		. .	4n

β 290. 34 Pegasi.

R. A. 22h 20m 30s Decl. + 3° 47′

1889.58	218°.6	2″.85	6	. . 12	1n

β 291.

R. A. $22^h\ 21^m\ 39^s$ Decl. $+\ 3°\ 55'$

1889.59 165°.0 0″.40 8 . . 8.5 1n

β 174.

R. A. $22^h\ 22^m\ 58^s$ Decl. $-\ 10°\ 17'$

1888.77 291°.7 8″.62 8.3 . . 10.7 3n

Σ 2912. 37 Pegasi.

R. A. $22^h\ 23^m\ 54^s$ Decl. $+\ 3°\ 49'$

1889.59 Apparently single.

β 703. α Lacertæ.

R. A. $22^h\ 26^m\ 20^s$ Decl. $+\ 49°\ 40'$

1888.71 297°.8 81″.59 . . 12.2 3n

β 77.

R. A. $22^h\ 27^m\ 51^s$ Decl. $-\ 2°\ 24'$

A and B.

1888.75 218°.3 2″.77 8.5 . . 8.7 3n

A and C.

1888.75 225°.6 28″.80 . . 11 3n

β 451. 15 Lacertæ.

R. A. $22^h\ 46^m\ 37^s$ Decl. $+\ 42°\ 40'$

1888.71 128°.5 29″.60 5 . . 12 3n

OΣ 482.

R. A. $22^h\ 47^m\ 55^s$ Decl. $+\ 82°\ 31'$

1889.31 35°.9 3″.40 5.2 . . 10.7 3n

β 382. B. A. C. 7983.

R. A. $22^h\ 48^m\ 18^s$ Decl. $+\ 44°\ 7'$

A and B.

1889.53 217°.6 0″.98 7.3 . . 8.8 3n

A and C.

1889.53 353°.7 26″.92 . . 10 2n

Σ 2959.

R. A. $22^h\ 50^m\ 55^s$ Decl. $-\ 3°\ 53'$

1889.73 102°.7 13″.37 7 . . 8.5 2n

Barnard. 2 Piscium.

R. A. $22^h\ 53^m\ 18^s$ Decl. $+\ 0°\ 19'$

1889.57 93°.6 3″.81 6 . . 13.7 3n

β 80.

R. A. $23^h\ 12^m\ 42^s$ Decl. $+\ 4°\ 45'$

1888.71 319°.5 0″.92 8.2 . . 8.9 4n

Ho. 199. 95 Aquarii.

R. A. 23h 12m 48s Decl. — 10° 16′

1888.72	222°.8	1″.22	4 . . 11.5	3n

β 718. 64 Pegasi.

R. A. 23h 16m 3s Decl. + 31° 9′

1888.80	85°.4	0″.67	5.8 . . 7.8	4n
1889.50	86°.2	0″.69	5.8 . . 8.8	3n

β 386. B. A. C. 8173.

R. A. 23h 21m 12s Decl. + 70° 1′

1888.71	318°.1	20″.69	7.2 . . 11.2	3n

Ho. 200.

R. A. 23h 24m 19s Decl. + 85° 45′

1889.31	142°.6	2″.38	6.6 . . 10.6	3n

OΣ 496.

R. A. 23h 24m 29s Decl. + 57° 58′

A and B.

1889.58	342°.1	1″.28	6 . . 11.5	3n

C and D.

1889.58	224°.1	1″.51	7.5 . . 8.6	3n

A and C.

1889.59	269°.0	75″.58	. .	2n

Σ 3022.

R. A. 23h 25m 7s Decl. + 57° 45′

1889.58	226°.3	20″.36	8.6 . . 9.1	3n

β 720. 72 Pegasi.

R. A. 23h 28m 0s Decl. + 30° 40′

1889.50	146°.0	0″.38	6 . . 6	3n

β 279. ω^2 Aquarii.

R. A. 23h 36m 30s Decl. — 15° 12′

1888.71	88°.3	5″.86	5.2 . . 11	3n

A. G. C. 14. 78 Pegasi.

R. A. 23h 37m 57s Decl. + 28° 42′

1889.48	197°.0	1″.44	5.5 . . 9.7	3n

Barnard. W[1] xxiii, 803.

R. A. 23h 40m 53s Decl. + 4° 35′

1889.57	166°.2	0″.54	8.6 . . 8.6	3n

β 995.

R. A. 23h 41m 35s Decl. + 46° 10′

1889.48	243°.4	0″.93	6.2 . . 10.2	3n

β 996.

R. A. 23h 46m 31s — Decl. + 74° 53′

1888.74	67°.1	5″.48	7.2	. .	12	3n
1889.51	68°.0	5″.77	6.4	. .	12.5	3n

β 730. 27 Piscium.

R. A. 23h 52m 32s — Decl. — 4° 13′

1889.57	267°.4	1″.50	5	. .	11.3	3n

β 733. 85 Pegasi.

R. A. 23h 55m 52s — Decl. + 26° 27′

A and B.

1888.69	126°.7	0″.95		. .		5n
1889.						

A and C.

1888.67	0°.9	21″.71		. .		5n
1889.50	358°.7	22″.66		. .	9	4n

A and D.

1888.69	283°.8	72″.02				1n

β 482.

R. A. 23h 56m 44s — Decl. + 62° 39′

A and B.

1888.71	343°.8	4″.60	9	. .	10	3n

A and C.

1888.71	123°.9	9″.79		. .	11.2	3n

Σ 3057.

R. A. 23h 58m 43s — Decl. + 57° 52′

1889.57	120°.1	3″.66	6.9	. .	9.1	3n

Σ 3062.

R. A. 23h 59m 57s — Decl. + 57° 46′

1889.57	321°.1	1″.45	6.5	. .	7.5	3n

ERRORS IN STAR CATALOGUES. By Prof. E. FRISBY, Washington, D. C.

THE NEW DEARBORN OBSERVATORY. By Prof. G. W. HOUGH, Northwestern University, Evanston, Ill.

ANNUAL PARALLAX OF SOUTH 503. By Prof. F. P. LEAVENWORTH, Haverford College, Pa.

THE SOLAR CORONA, A PHENOMENON IN SPHERICAL HARMONICS. By Prof. FRANK H. BIGELOW, Nautical Almanac Office, Washington, D. C.

FORMULA FOR THE PROBABILITY OF ANY FACT OR OCCURRENCE ABOUT WHICH ANY NUMBER OF WITNESSES MAY TESTIFY. By J. E. HENDRICKS, Des Moines, Ia.

METHOD OF FINDING FACTORS. By JAMES D. WARNER, Brooklyn, N. Y.

DRAFT OF A MEMORIAL RELATIVE TO UNIVERSAL TIME. By C. CARPMAEL, President of the Canadian Institute, and A. MACDOUGALL, Toronto, Can.

[After discussion in the section, this memorial was referred to the Council, and a special committee was appointed to report at the meeting of 1890.]

SECTION B.

PHYSICS.

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ADDRESS

BY

PROFESSOR HENRY S. CARHART,

VICE PRESIDENT, SECTION B.

REVIEW OF THEORIES OF ELECTRICAL ACTION.

THE Physics Section of this Association congratulates itself because it deals with topics of the most lively interest, not only from a practical point of view but still more from a theoretical one. Even popular interest in electricity is now well-nigh universal. Its applications increase with such prodigious rapidity that only experts can keep pace with them. At the same time the developments in pure electrical theory are such as to astound the intelligent layman and to inflame the imagination of the most profound philosopher.

Of the practical applications of electricity it is not necessary to speak. They bear witness of themselves. A million electric lamps nightly make more splendid the lustrous name of Faraday; a million messages daily over land and under sea serve to emphasize the value of Joseph Henry's contribution to modern civilization. Blot out these two names alone from the galaxy of stars that shine in the physical firmament, take from the world the benefits of their investigations, and the civilization of the present would become impossible. The value of the purely scientific work of such men is attested by the resulting well-being, comfort and happiness of mankind.

But the mind can never rest satisfied with the facts and applications of a science however interesting and useful they may be. It feels an inward impulse to link the facts into a related whole, to inquire into their causes, to frame a satisfactory theory of their

correlation, and so to build on them a true science. It is, indeed, interesting to study the history of any scientific doctrine and to trace its development from the crude notions of its earliest stages to the more refined conceptions of later periods, comporting indefinitely better with the marvelous processes of nature. Such a history we have in the views which have been held regarding the nature and action of electricity. The transition from the glutinous effluvium of the sagacious Robert Boyle to the magnetic and electric waves of the present, traversing the omnipresent ether with the velocity of light, is not an easy one to make even in a period of two hundred years. For more than twenty centuries natural philosophers had nothing better than the emission theory to account for the attraction exhibited by rubbed amber and other similar substances. Their notion was that the rubbing of the amber caused it to emit an effluvium which returned again to its source and carried light bodies back with it.

In one respect this fanciful attempt to explain electrical action deserves commendation; for it evinces a mental inaptitude to account for physical action "at a distance," or without some intermediate agency. Later philosophers, satisfied perhaps too easily with mathematical explanations founded on the observed laws of attraction and repulsion and not demanding a medium, did not feel the same intellectual necessity of filling the space between bodies acting on one another, either with emanations from those bodies, or with an invisible, imponderable medium, suspected by no sense of man but required only to meet a demand of his highest intelligence. For when the Newtonian philosophy had made some progress the doctrine of unctuous effluvia was given up, and physicists acquiesced in the unexplained principle of attraction and repulsion as properties of bodies communicated to them by the Divine Being, the mechanism of which they scarcely attempted to explain (Priestley). "Many superficial philosophers thought they had given a very good account of electricity, cohesion and magnetism by calling them particular species of attraction peculiar to certain bodies."[1]

The discovery of Stephen Grey that the "electric virtue" could be conveyed along a wire for several hundred feet without sensible diminution, and the invention of the Leyden jar by Kleist or Cuneus, had the effect of annihilating many mushroom theories con-

[1] Priestley's Hist. of Elect., Vol. 2, p. 18.

structed on the slimmest basis of facts. The latter discovery disclosed a power in electricity not previously suspected, and excited the greatest interest both in Europe and America. At this period Franklin turned his attention to the subject, and "spent more time in diversifying facts and less in refining upon theory" than some of his European contemporaries. In fact, he tells us that he was never before engaged in any study that so totally engrossed his attention and his time.

His discovery that the two electricities are always excited in equal quantities, that the charge resides on the glass and not on the coatings of the Leyden jar, and his experimental identification of lightning with frictional electricity excited the liveliest interest abroad and secured for him the Copley medal of the Royal Society; while his theory of positive and negative electricity made a permanent addition to the nomenclature of the science. His conceit that a turkey, killed with the discharge of a battery of jars, was uncommonly tender eating, a discovery gravely communicated to the Royal Society by William Watson, is not so well known and does not appear up to the present to have been verified.

We cannot agree with him, I am sure, when he says, "nor is it of much importance for us to know the manner in which nature executes her laws; it is enough if we know the laws themselves." For the pursuit of the manner in which nature executes her laws is the distinguishing characteristic of the science of the present day. It has led to most brilliant discoveries, and it bids fair to do more than all other agencies combined to show the intimate and necessary relations existing between the different branches of physics. We need to be reminded often that accumulated facts do not constitute a science, and that utility is not the highest reward of scientific pursuits. A bit of polished marble plucked from the ruins of the Roman Palatine Hill is an interesting relic; but how much more interesting to reconstruct the palace of Nero and to see this fluted marble in its proper and designed relation to the whole of which it was once a necessary part! Science is constructive. Laws are derived from an attentive consideration of facts; generalizations group laws under broader relationships; and great principles unite all together into one related, impressive whole.

From the time when the famous Boyle caught sight of a faint glimmer of electric light to the present, physicists have been in pursuit of the connection between light and electricity. As early

as Newton's time, the ether was conceived by some to be a very subtle medium confined to small distances from the surfaces of bodies and to be the chief agent in all electrical phenomena. But, says Priestley,[1] "the far greater number of philosophers suppose, and with the greatest probability, that there is a fluid *sui generis* principally concerned in the business of electricity. They seem, however, though perhaps without reason, entirely to overlook Sir Isaac Newton's ether; or if they do not suppose it to be wholly unconcerned, they allow it only a secondary and subordinate part to act in this drama." Among the branches of knowledge that this writer recommends as likely to be of service in the study of electricity is the doctrine of light and colors.

The invention of the Voltaic battery and Sir Humphrey Davy's celebrated experiment in producing the electric arc stimulated inquiry in this same direction. Mrs. Somerville, Morrichini and others sought to produce magnetism by means of sunlight, but ultimately, as is now known, without success.

Notwithstanding these negative results, Faraday had such a "strong persuasion derived from philosophical considerations" of a direct relation between light and electricity, that he resumed the inquiry in a most searching manner, with the happy result of discovering the rotation of the plane of polarization of light by means of magnetism. "Thus is established," he says,[2] "a true, direct relation and dependence between light and the magnetic and electric forces; and thus a great addition [is] made to the facts and considerations which tend to prove that all natural forces are tied together and have one common origin."

It was thus reserved for Faraday to make those discoveries and to obtain that insight into electric and magnetic action which were needed by his great disciple and interpreter Maxwell to construct a most marvelous theory of the connection between these two departments of physical science.

Respecting the failures to obtain magnetism from the direct action of sunlight, to which allusion has been made, Maxwell says that we should not expect a different result because the distinction between magnetic north and south is one of direction merely; that there is nothing in magnetism indicating such opposition of properties as is seen at the positive and negative poles of a battery

[1] Hist. of Elect., Vol. 2, p. 22.

[2] Exp. Researches, 2221.

in electrolysis; that even right and left handed circularly polarized light cannot be considered the analogue of the two poles of a magnet, for the two polarized rays when combined do not neutralize each other but produce plane polarized light.

It may be said, however, that if a right-handed, circularly polarized ray produces magnetism in one direction and a left-handed ray in the opposite, then the combination of the two rays may neutralize their magnetic effect, inasmuch as plane polarized light may have no magnetic influence. Prof. J. J. Thomson has lately shown mathematically[1] that a circularly polarized ray does have a magnetic effect, but that it is so small, even with strong sunlight, as to be much beyond the limits of experiment; and Mr. Shelford Bidwell[2] has produced a bar of iron in such an exquisitely sensitive magnetic state that magnetic changes are certainly produced in it by the direct action of light. This he has accomplished by rendering the bar more susceptible to magnetic influences in one direction than the other. We may not, I venture to affirm, be without hope that magnetism and electric currents may yet be evoked by the direct agency of sunlight.

Faraday was deeply convinced that space has magnetic properties, and that the space or medium round a magnet is as essential as the magnet itself, being a part of the magnetic system. To him all magnetic and electric action took place by contiguous particles along lines of force. "What that magnetic medium, deprived of all material substance, may be, I can not tell," he says,[3] "perhaps the ether." No doubt existed in Faraday's mind that these lines of force represent a state of tension; but whether that tension is a static state in the ether, or whether it is dynamic, resembling the lines of flow of a current between the poles of a battery immersed in a conducting fluid, was uncertain. He inclined, however, to the latter view. He was thus led to advocate, though not without hesitation, the physical nature of lines of force.

Faraday's discoveries, and his method of regarding all magnetic and electric actions as propagated through a medium by means of contiguous parts, have been of the utmost productiveness. They have revolutionized the science of electricity, and have been the most potent factors in the genesis of a theory, including all ra-

[1] Applications of Dynamics to Physics and Chemistry, p. 78.
[2] London Electrician, March 22, 1889.
[3] Exp. Researches, 3277.

diant energy, which has recently received such remarkable and conclusive confirmation. His name has become almost a household word. His earnest, unselfish life has added unnumbered millions to the world's wealth. His ideas and words, which have been instruments in the hands of philosophers, have become the current coin of the commercial tyro, who talks as glibly about lines of force and the magnetic circuit as if—he really knew something about them.

Fruitful as Faraday's ideas were they yet awaited a mathematical interpreter for their highest development. A good Providence sent James Clerk Maxwell, whose brilliant mathematical ability was equaled by his philosophic insight, his poetic feeling and imagination, his profound sincerity and his great sympathy with nature. Hear him sing at Aberdeen :—

"Alone on a hillside of heather,
I lay with dark thoughts in my mind,
In the midst of the beautiful weather,
I was deaf, I was dumb, I was blind.
I knew not the glories around me,
I counted the world as it seems,
Till a spirit of melody found me,
And taught me in visions and dreams."

"For the sound of a chorus of voices
Came gathering up from below,
And I heard how all Nature rejoices,
And moves with a musical flow.
Oh! strange! We are lost in delusion,
Our ways and our doings are wrong,
We are drowning in wilful confusion
The notes of that wonderful song."

To appreciate Maxwell's relation to theories of electrical action it is desirable to take a retrospect of the views that have been held regarding its nature. Three periods in the history of these views may readily be distinguished. The first was introduced by Dr. Gilbert in 1600 and it lasted about two hundred twenty-five years. The little that was known previous to Gilbert constitutes only the preface or introduction to the history proper. Nearly three-fourths of this period was utterly barren and unfruitful. It knew nothing better than unctuous effluvia and electric atmospheres. In the latter half of the period the Newtonian philosophy had become the orthodox doctrine. The great success attending the mathematical

investigations founded upon the law of inverse squares naturally carried with it the acceptance of the underlying hypothesis of "action at a distance." There were not lacking, indeed, men of deeper philosophic insight who denied this doctrine, which they looked upon as entirely unphilosophical and which must utterly bar the way to any inquiry into the process by which the law is executed. Action at a distance by attraction or repulsion, varying inversely as the square of that distance, means an ultimate fact not admitting of further analysis.

The second period was one of contention. It began not with the important discovery of current electricity, nor of the electro-magnet, but with the philosophical methods and concepts of Faraday. The physical postulates of the mathematical school were entirely alien to the views which he adopted. "Faraday, in his mind's eye, saw lines of force traversing all space where the mathematicians saw centers of force attracting at a distance; Faraday saw a medium where they saw nothing but distance; Faraday sought the seat of the phenomena in real actions going on in the medium, they were satisfied that they had found it in a power of action at a distance impressed on the electric fluids."[1] Prior to Faraday the supporters of a medium to explain electric and magnetic action were always thrown out of court for lack of evidence; Faraday gave them a legal standing by furnishing the facts and evidence on which they could well afford to base their case.

The corpuscular theory of light, which had shown such remarkable vitality, was now in the last stages of a fatal disease due to indigestion and lack of assimilation. Foucault finished it off in 1865 with his crucial experiment to decide upon the relative velocity of light in air and water. The undulatory theory was thus fully established, and the doctrine of radiant energy in general began to be clearly apprehended. The grand generalization of the Conservation of Energy was looming up all along the horizon of science, as the towers and spires of a great city appear to rise out of the sea to a traveller approaching the land. Victory was ready to perch on the banners of an army contending for the ether doctrine—not a decimated army but one constantly augmenting in numbers by deserters from the enemy.

At this period, sixteen years ago, appeared the epoch-making book of Maxwell on Electricity and Magnetism. Its author professes

[1]Maxwell's Elec. and Mag., p. x.

only to translate Faraday's ideas into mathematical language; but he did vastly more than this. He demonstrated mathematically that the properties of the medium required to transmit electromagnetic action are identical with those of the luminiferous ether. It would be unphilosophical, he remarks, to fill all space with a new medium whenever any new phenomenon is to be explained; and since two branches of science had independently suggested a medium requiring the same properties to account for the same phenomena in each, the evidence for the existence of a single medium for both kinds of physical phenomena was thereby greatly strengthened. The step from identity of the medium to identity of phenomena, that is, that light itself is an electromagnetic phenomenon, though it may now seem to be a short one, must nevertheless upon careful consideration always be accepted as evidence of the greatest genius. To walk in Maxwell's footsteps now and take the very steps he took is one thing and a comparatively easy one; but to make original explorations into unknown regions of nature and to tread where no human being has ever before set foot is quite another thing. The electromagnetic theory of light must be regarded as a great generalization inferior only to that greatest one of all time — the Conservation of Energy.

The principal criteria upon which Maxwell relied for the confirmation of his theory may be briefly enumerated:—

1. An electromagnetic wave or undulation is propagated through the ether with a velocity equal to the ratio of the electromagnetic to the electrostatic unit of quantity. If light is an electromagnetic phenomenon its velocity must also be equal to this same ratio. The very close approximation of the one to the other, as determined by a variety of methods, has been known for some time.

2. The specific inductive capacity K of any transparent medium or dielectric should equal the square of its index of refraction. The discrepancies at this point are so great that all one can say in the most favorable case is that K is the most important term in the expression for the refractive index; while in other cases no confirmation whatever can be drawn from this class of evidence.

3. The magnetic and electric disturbances are both at right angles to the direction of propagation of the wave and at right angles to each other. The mathematical form of the disturbance agrees with that which constitutes light in being transverse to the direction of propagation. Further, the *electric* disturbance should

be perpendicular to the plane of polarization of plane polarized light.

4. In non-conductors the disturbance should consist of electric displacements, but in conductors it should give rise to both electric displacements and electric currents by which the undulations are absorbed by the medium. Most transparent bodies, it is true, are good insulators and all good conductors are opaque. The opacity is, however, far from being proportional to the conductivity.

5. But perhaps the most important criterion of all is the one relating to the very existence itself of a medium. Such a test lies in the *time element* involved in transmission from point to point. Since energy is transmitted from a luminous body as the source to another one which may absorb it, then plainly if time is required for the transmission, the energy must reside in the medium by which the transmission is effected during the interval between the emission and the absorption. In the emission theory the light corpuscles are the receptacles of the energy and carry it with them in their flight. According to the undulatory theory the medium filling all space is the receptacle of the energy and passes it along from point to point by the action of contiguous parts. Foucault's *experimentum crucis* proved the emission theory untenable. Roemer's observation of the retardation of the eclipses of Jupiter's satellites when the earth is moving away from Jupiter, is therefore a confirmation of the undulatory theory of light; and, in consequence, a demonstration of the existence of the luminiferous ether.

At this point the history of the nature of electric action touches upon the third period.

The period upon which we have just entered may not inappropriately be called the period of confirmation. Nothing further appears to be necessary for the complete demonstration and establishment of the electromagnetic theory of light. The noteworthy experiments of Professor Hertz of Carlsruhe are known to all. Rightly conceiving that the reality of electromagnetic waves would be best established by the same experiments which would establish the fundamental identity of such undulations with those of light, he had recourse to the principle of resonance or sympathetic vibrations for the detection of these long-period waves. By a device no less remarkable for its simplicity than its effectiveness he produced electric oscillations of such rapidity that the waves in the surrounding region were short enough to be measured. This he accomplished

by attaching to the secondary terminals of an induction coil two rectangular sheets of metal, each supplied with a short, stout wire ending in a small ball. The balls were brought near each other and the discharges of the coil took place between them. Under these conditions the discharge is oscillatory, and the period may be calculated by the formula of Sir Wm. Thomson published in 1853.[1]

The receiving apparatus is also of the simplest design, consisting ordinarily of a circle of wire interrupted at a point with an adjustable opening, and of such dimensions that the waves passing through the circle may set up electric oscillations in it synchronizing with those of the transmitting apparatus. The passage of sparks across the narrow opening of the circle indicates an electrical flow; and the necessity of adjusting the size of the circle in order to obtain this flow proves that the forces acting are periodic. The receiving apparatus must in fact be tuned so that the period of an electrical oscillation in it shall correspond with the external impulses absorbed. The intensity of the electric and magnetic disturbances is indicated by the relative length of sparks obtainable.

Equipped with this apparatus, which was installed in a large lecture hall, Hertz found not only that his tuned receiver responded to the impulses of the transmitter in the precise manner pointed out by theory, but that the sparks showed a series of maximum and minimum values recurring in periodic order as the receiver was carried further away from the source of the disturbance. The astounding fact was thus brought out that these electromagnetic waves were reflected from the thick wall of the room, and that the combination of the direct and reflected systems produced stationary waves with loops and nodes that could be traced out by the responsive circle of wire. In this manner wave-lengths were measured down to 60 cms., and the time element was experimentally detected in the propagation of electrostatic and electrodynamic induction. It was demonstrated that the disturbances producing the waves are at right angles to the direction of propagation, as Maxwell predicted and as interference phenomena show them to be in light. Hertz has also found an electrodynamic shadow cast by an iron post; he has verified the laws of reflection from plane and concave reflectors, and has shown that electric waves suffer refraction and polarization in a manner exactly analogous to light. Professor Fitzgerald of Dublin has added another confirmation of Maxwell's doctrine, demon-

[1] Math. and Phys. Papers, Vol. 1, p. 540.

strating that the *electric* disturbance is perpendicular to the plane of polarization, as Maxwell's equations require. Finally, the velocity of propagation of these electrodynamic waves is found to be the same as the velocity of light. Thus not only have all of Maxwell's criteria except the second abundantly confirmed the judgment of the great physicist, but other proofs have been added.

Electromagnetic waves are therefore not only like light but they are light. Or, perhaps to speak more exactly, all radiant energy is transmitted as electromagnetic waves in the luminiferous ether. Electricity has thus annexed the entire domain of light and radiant heat; and, as Professor Lodge says, has become a truly imperial realm. The difference of wave-length in the three classes of phenomena is not a fundamental one. Increase the rate of the electrical oscillations a million fold in Hertz's experiments and the waves would not merely resemble light—they would be light. A wire through which such oscillations are surging back and forth would glow with light. Even the long heat waves would be absent and only those producing the sensation of light and color would remain.

It will be observed that the oscillations of an electric discharge constitute the point of departure for the admirable researches of Hertz; and it is a matter in which we may modestly take a bit of national pride that the first case of electric oscillations was discovered by an American physicist. The oscillatory character of the Leyden jar discharge was demonstrated by Joseph Henry in 1832 by means of the magnetic effects produced in small steel needles. It was not till twenty-one years later that Sir Wm. Thomson published the complete mathematical theory of such oscillations. They have since been observed directly by means of a rotating mirror. Dr. Oliver Lodge has recently shown that they rotate the plane of polarization of light in one direction and then the other as they surge back and forth. He has also reduced the number of oscillations from several millions to a few hundred per second by increasing the capacity and the self-induction. The discharge then vibrates within the limits of audibility and produces a musical note.

The well-known experiment of Henry, in which he observed an induction current in a wire stretched parallel to and distant thirty feet from one which served to discharge a Leyden jar, is now known to have been a case of resonance, that is, the absorption of electric waves by a conductor producing currents therein. And it is an evidence of the great genius of Henry that he saw, somewhat dimly it may be, but still with a certain degree of rational apprehension,

that the induction was transmitted across the intervening space with a velocity comparable only to that of light. He had perchance the divine touch of genius necessary for the great discovery of electromagnetic waves coursing through the ether; but the way leading to this important physical fact had not then been sufficiently prepared and its discovery was impossible.

Waves similar to those of a Leyden jar discharge but of longer period are sent out from a wire conveying alternating currents. We must conceive of such a wire not simply as affected internally or even superficially by the electric energy surging through it, but as the source from which pulsate outward through the limitless ether great waves of electrodynamic disturbance. For three hundred complete alternations per second, these waves are a million meters, or over six hundred miles, in length. They present a marked contrast to the waves corresponding to the D lines of the spectrum which are only about one five-millionth of a millimeter long.

These long waves from an alternating current represent energy. Through space it is conveyed with the velocity of light, and through other non-conductors or dielectrics with a smaller velocity, precisely as in the case of the radiant energy of light or heat. Henceforth the complete equation for the distribution of energy by means of alternating currents must include a term to express the radiation from the circuit. It may indeed be found that this term represents no inconsiderable part of the energy communicated to the wire in the case of very rapid alternations.

Thus we see that the ether plays a magnificent *rôle* in what may be called its dynamic relation to electric displacements. In its capacity, as a reservoir of static or potential energy, its agency has been better understood for a considerable period. When a continuous current begins to flow through a closed circuit a single wave travels out from the conductor; and during its progress, while the current is approaching its constant value, the enclosing ether is assuming its condition of static repose under stress. The whole ether, extending indefinitely outward from the conductor, is profoundly modified. We know how to map out the circular lines of force about it by means of iron filings; but the iron serves only to show what has already taken place in the ether before the filings are brought into the field. Every little iron particle becomes a magnet with all the north-seeking poles stretching in one direction round the wire, and all the south-seeking poles in the other. What the mechanism of the stress, or the motion in the ether to produce these effects may

be, we do not know; but we do know that these lines of force are all subject to a tension tending to shorten them, and that they are mutually repellent laterally. When a current is sent through a conductor the ether is expanded in concentric cylindrical layers about any straight portions of the circuit, and becomes the reservoir of potential energy. As soon as the current which maintains this state of tension ceases to flow the stretched ether collapses upon the conductor, yielding up its energy in the form of self-induction. If a steady current is conceived as the setting up and breaking down of a static difference of potential at infinitesimal intervals of time, then the energy transmitted may depend upon a similar formation and decay of the static stress in the encompassing ether. The conductor is but the core of an electromagnetic disturbance in the surrounding medium; and it may be that the enormous energy which a small copper wire can apparently convey is in reality transmitted by the invisible medium.

From this brief review of the theory of electric action it will be quite evident that henceforth the language applied to electrical phenomena must always include as a prominent term the luminiferous ether. The experiments of Hertz have made it impossible to explain electrical facts without taking this invisible medium into account. There is no such thing as electric or magnetic action at a distance. The ether is always an essential part of that complex system the interactions of which manifest themselves as electric or magnetic phenomena.

As the ear responds to the slow oscillations of an electric discharge through the intermediate agency of heat, so the eye of the mind responds to those more rapid oscillations the existence of which has been demonstrated by experiment. No less clearly does the magnetic field appear as a system of lines of stress in the ambient ether. Definiteness has taken the place of the metaphysical speculations of earlier times. Complete ignorance has at least been superseded by half knowledge. We may not yet affirm with Edlund that the ether *is* electricity, but we are doubtless nearer a solution of this old problem than ever before.

"The discord is vanishing slowly,
And melts in the dominant tone.
And they that have heard it can never
Return to confusion again,
Their voices are music forever,
And join in the mystical strain."

PAPERS READ.

ON THE PARTITION OF THE MEAN KINETIC ENERGY OF A PERFECT GAS BETWEEN THE ROTARY AND TRANSLATORY MOTIONS OF ITS MOLECULES. By Prof. H. T. EDDY, Cincinnati, Ohio.

[ABSTRACT.]

CONSIDERING a molecule to be a free body, which has motions of rotation and translation with respect to each of its three principal axes of inertia, let us fix our attention upon the motion with respect to one only of these axes and call it, for convenience, x.

The actual motion at any instant with reference to x is on a screw of some determinate pitch of which x is the axis. In the paper before us this actual screw motion is resolved into two screw motions both about x, and of such pitch that they perfectly replace the single screw motion both kinematically and kinetically. It is shown that this condition holds when the original screw motion is replaced by a motion compounded of motions upon two screws, one right-handed and the other left-handed, of which the pitch of both is, under all circumstances, constant and equal to the radius gyration of the molecule about x.

It further appears that since during the fortuitous molecular encounters which control the rotary and translatory motions, the rotary impulses about x are independent of the translatory impulses along x, there is no more probability that a positive rotary impulse will be associated with a positive translatory impulse than with a negative translatory impulse. Hence, motions on each of the component screws are independent and equally probable.

But in each of the component screw motions into which the actual motion has been resolved, the total energy is half of it rotary and half of it translatory. Hence the total kinetic energy of the molecule is half rotary and half translatory.

NOTE ON THE MAGNETIC ROTATION OF POLARIZED LIGHT ACCORDING TO THE ELECTRO-MAGNETIC THEORY. By Prof. H. T. EDDY, Cincinnati, Ohio.

[ABSTRACT.]

PARTIAL differential equations, expressing the propagation of plane polarized light in a magnetic field, have been published by Professor Row-

land in the Am. Jour. Math., Vol. III, p. 109, into which he has introduced terms expressing the transverse electromotive force due to the Hall effect.

The particular solution of these equations which he proposes contains a periodic factor dependent upon the time.

In this note a different, particular solution, containing a periodic factor dependent upon the space which the ray traverses in the field, is discussed at length and compared with the solution proposed by Professor Rowland.

It is shown that the amount of the magnetic rotation would be the same whichever form of solution we adopt, but that the velocity of the ray would be increased if there is a periodic factor dependent upon the time alone, but the velocity would be decreased by a periodic factor dependent upon the space.

The physical ideas connected with this manner of propagation of light are such as to lead us to regard a decrease of the velocity by the transverse electromotive force arising from the Hall effect as extremely probable.

Preliminary experimental investigations, made conjointly by Prof. Thos. French, jr., and the author, have as yet led to no decisive result.

In the last part of this note the author has examined the more general solution of these differential equations containing a periodic factor dependent upon both time and space.

AN APPARATUS FOR THE EXPERIMENTAL SOLUTION OF THE PROBLEM STATED IN PROFESSOR EDDY'S PAPER ON THE MAGNETIC ROTATION OF POLARIZED LIGHT. By Prof. EDWARD W. MORLEY, Cleveland, O.

[ABSTRACT.]

IT is required to determine whether the velocity of light in carbon bisulphide is affected by a magnetic field. The apparatus is intended to apply the method of interferences to the measuring of the difference of velocity in question, and also at the same time to the determining the constancy of position of certain parts of the optical apparatus used, so as to detect an effect even if it be very small.

RELATIVE MERITS OF DYNAMOMETRIC AND THE MAGNETIC METHODS OF OBTAINING ABSOLUTE MEASUREMENT OF ELECTRIC CURRENTS. By Prof. THOMAS GRAY, Terre Haute, Ind.

[ABSTRACT.]

THIS paper consists of a discussion of the methods commonly adopted for the measurement of electric currents by the electrodynamic and the

magnetic methods. The methods of determining the value of the horizontal intensity of the terrestrial magnetic field and of using it in the current measurement are examined and some modifications in the detail of the method are suggested both in the ordinary Gauss and in the suspended coil Kohlrausch method. The measurement of the dimension of standard galvanometer coils is also examined in connection with this method and a means of obtaining high accuracy described.

The degree of accuracy attainable from the instrumental point of view is found to be within one-twentieth per cent of absolute.

In the dynamometric method a general agreement is expressed with the position taken up by Lord Rayleigh and the opinion given that this method could be made to give an accuracy within one-hundredth per cent of absolute.

As to secondary standards, the magneto-static galvanometer, the electro-chemical equivalents of silver and copper and the standard balance as designed by Thomson, are each considered and a preference expressed for the balance, with occasional redetermination of the constant by electrolysis, as the most convenient and reliable instrument for ordinary use.

Experiments for demonstrating that the force of a detonating explosive is exerted in all directions about the explosive centre. By Prof. Charles E. Munroe, U. S. Torpedo Station, Newport, R. I.

[ABSTRACT.]

There is a popular belief that the force of exploding gunpowder is exerted upwards, while that of the detonating high explosives is exerted downwards, and that this belief is shared by some men of science is shown by a statement of L. Gattermann in Ber. d. chem. Ges., XXI, 751–757, 1888, that it is a characteristic of nitrogen chloride that the explosion takes place in a downward condition.

In the experiments described, equal and similar masses of gun-cotton are placed on an iron plate suspended horizontally in mid-air. One mass of gun-cotton is placed on the upper surface of the plate, in the centre of one-half, while the other mass of gun-cotton is placed on the under surface and in the centre of the other half of the plate. The detonators in the gun-cotton blocks are connected in series and fired simultaneously and from inspection of the effects produced, it is impossible to tell which was the upper and which the lower surface of the plate.

Again, a detonator, containing thirty-five grains of mercury fulminate, is fired in a closed cylindrical vessel of iron filled with water, when by the action of the detonator the vessel is forced into a nearly spherical shape.

A QUADRANT ELECTROMETER. By Prof. HARRIS J. RYAN, Ithaca, N. Y.

[ABSTRACT.]

THE electrometer needle and quadrants are made of the cylindrical form. To the needle is attached a magnetized steel mirror.

The needle is hung by a single silk fibre and metallie contact is made to the same by means of a very fine platinum wire.

About the quadrants and needle, with its plane in the magnetic meridian and the steel mirror at its centre, is arranged a coil of wire, as in a tangent galvanometer.

The electrometer needle is deflected and then brought back to its "zero" position by balancing with a current in the coil surrounding the same, whereby the magnetized mirror is acted upon by a couple opposite of sign to that acting on the needle. The current is then a measure of the difference of potential to which the electrometer has been subjected, in accordance with the manner in which it may have been arranged.

A SOLAR CONDITION UPON WHICH THE AURORA DEPENDS. By Dr. M. A. VEEDER, Lyons, N. Y.

[ABSTRACT.]

IN this paper a comparison is made between the record of auroras reported from signal service stations in the United States and that of the daily condition of the sun made by the writer for three years from April, 1886 to April, 1889. In general, it is found that the aurora is rarely seen at a single station for two nights in succession, but is usually reported from different stations for about four days at each manifestation. Recurrence at intervals corresponding very closely to the time of the rotation of the sun is common. During 1888, eighteen such instances were noted, in which the beginnings of the attendant magnetic perturbations, as shown by the tracings from the declination magnetograph at the Naval Observatory, Washington, were so abrupt, that it might be possible by this means to determine the time of the revolution of the sun, the average period thus found being twenty-six days and eight hours. In 1886 also, there were seven returns at like intervals, forming a single series of the finest auroras during the entire three years. A comparison of the tracings of the magnetograph shows that the average duration of each outbreak is not far from four days.

This behavior of auroras and magnetic storms indicates that any solar disturbance which may originate them has this power during a limited portion only of its transit across the earthward side of the sun. Although such disturbance may remain active throughout successive returns, the earth remains within range of its impulse during only about four days at each transit. During the three years in question, there were one hun-

dred and eighty-eight characteristic outbreaks of the aurora, as above described; for twenty-six of these, observations are lacking. In connection with the remaining one hundred and sixty-two, in every instance more or less bright faculæ with or without dark spots was upon the sun's eastern limb appearing by rotation. In a very large proportion of cases these solar disturbances were so evidently active and isolated upon the sun's disc that the conclusion is very strongly justified that spots and faculæ in this particular location have the power of originating auroras. On the other hand, in very numerous instances, extensive outbreaks elsewhere were not attended by the aurora. In only twenty-two instances were spots and faculæ appearing by rotation not attended by the aurora within the United States. The majority of these cases were in June and July and the aurora was probably visible in higher latitudes, there having been decided magnetic perturbations, so far as tracings from the magnetograph are at hand.

It is noteworthy that an increase in the number of stations reporting thunderstorms, as a rule, follows the appearance by rotation of solar disturbances, although a very bright aurora may be attended by some temporary decrease for a day or so, as though it had taken their place. The curve, denoting the number of stations reporting winds above fifteen miles at seven A. M. each day, also rises as a rule whenever a solar disturbance is appearing by rotation, but this curve corresponds more closely to that of thunderstorms than that of auroras.

Essentially, this paper is a bare synopsis of the results of daily observations and is intended as a report of progress. No attempt is made to account for the grouping of phenomena revealed, although it is evident that the subject has an important bearing upon many questions in physics.

A PRELIMINARY REPORT ON THE INFLUENCE OF TEMPERATURE UPON THE COLOR OF PIGMENTS. By Prof. EDWARD L. NICHOLS AND BENJAMIN W. SNOW, Cornell University, Ithaca, N. Y.

[ABSTRACT.]

IN this investigation a variety of substances, most of which were metallic oxides, were illuminated by an incandescent lamp, held at constant candle-power. The light reflected by them at the temperature of the room, and at various high temperatures, was then subjected to a spectrophotometric analysis. For this purpose each substance in the form of a uniform film of dry powder, was placed upon the surface of a strip of platinum foil. The foil was heated to the point at which measurements were to be made, by means of the current from a storage battery; its temperature being determined from the linear expansion.

The general law commonly supposed to hold, that the change of color in pigments, with rise of temperature, is always "towards the red," was not substantiated. It was found, however, without exception, that the substances experimented with suffered decrease of reflecting power when

heated; and that all wave-lengths of the visible spectrum were subjected to greater absorption by the hot than by the cold pigment. In some cases this increased absorption occurred in nearly like proportion throughout the spectrum; in other cases it was selective.

The authors hope in the near future to extend their measurements to a much larger number of substances, including many organic compounds.

AN IMPROVED CLARK STANDARD CELL WITH LOW TEMPERATURE COEFFICIENT. By Prof. H. S. CARHART, Ann Arbor, Mich.

[ABSTRACT.]

THE paper describes first the improvements desirable in a standard cell. Some directions are then given respecting the preparation of materials for such a standard.

Some account of the local action going on in the old type of Clark cell in which zinc replaces mercury in the mercury salt. The temperature coefficient of these new cells is represented by the equation

$$E. M. F. = E\,[1 - 0.000387\,(t - 15) + 0.0000005\,(t - 15)^2].$$

It will be seen that the coëfficient diminishes slightly as the temperature rises, while in Lord Rayleigh's cells it increases with rise of temperature.

Method of comparing E. M. F.'s described.

The E. M. F. of a cell prepared by my method is three or four-tenths per cent higher than the Lord Rayleigh form.

The polarization in these cells amounts to one ten-thousandth part in five minutes when closed on an external circuit of 10,000 ohms.

[Printed in full in the AMERICAN JOURNAL of SCIENCE, November, 1889.]

MAGNETIC LEAKAGE IN DYNAMOS. By Prof. H. S. CARHART, Ann Arbor, Mich.

[Printed in full in the WESTERN ELECTRICIAN (Chicago), Aug. 31, 1889; and in the London ELECTRICAL REVIEW, Sept. 15, 1889.]

CONCERNING THERMOMETERS. By Prof. WM. A. ROGERS, Waterville, Me., and Prof. R. S. WOODWARD, Washington, D. C.

[ABSTRACT.]

(Part I by Wm. A. Rogers.)

(1) The movement of a mercurial column is by pulsations.

(2) These pulsations have a regular recurrence.

(3) The range of pulsations is constant in the same thermometer and varies between 0.25° and 1.1° in the different thermometers investigated.

(4) Every pulsation has the same harmonic relation, whatever the part of the scale at which the reading occurs.

(5) The amplitude of the curve which represents this harmonic is a constant and varies between 0.13° and 0.53° for the thermometers investigated.

(6) Since the range of pulsations is constant and the time required for the completion of the cycle is variable, it follows that the danger of error in random readings of the thermometer is greater for slow than for rapid variations of temperature.

(7) Method of reading thermometers by which the errors in question are eliminated.

(8) A part of the errors in question are undoubtedly due to the personality of the observer in estimating the fractional subdivisions of the scale but the errors still remaining are periodic in their character. In any event, the mean of the readings taken at equal intervals of time throughout a complete cycle of changes, will be substantially free from errors of the class pointed out in this paper.

(Part II by R. S. Woodward.)

The object of this paper is to give a theoretical explanation of the periodic or pulsating movement of a mercurial thermometer column discovered and described by Prof. W. A. Rogers. The theory applies to all thermometers of the mercurial thermometer type, and it may be called the dynamical theory of such thermometers.

It is assumed that the column of the thermometer is subject to the action of the following forces: (1) the elasticity of the bulb generated by the expansion of the liquid of the thermometer; (2) the mass or inertia of the column; and (3) the frictional and other resistances, including whatever effect may arise from surface tension at the end of the column.

Let

v_0 = volume of liquid in bulb at time $t = 0$,
v = volume of liquid in bulb at time $t = t$,
m_0 = mass of liquid in column at time $t = 0$,
s_0 = length of column at time $t = 0$,
Δs = rise of column in time t,
ω = cross-section of column,
ϵ = coëfficient of expansion of the liquid,
τ = temperature of liquid in bulb at time t,
ρ = density of liquid in column at time t,
r = rate of temperature rise = $\frac{d\tau}{dt}$,
F = frictional and other resistances.

It is evident that

$$v = v_0 + v_0\epsilon\int_0^t r dt - \omega\,\Delta s;$$

and if p be a suitable factor, the increment of pressure generated by the expansion of volume v in the instant dt will be

$$pv\varepsilon r dt = p\varepsilon \left(v_0 + v_0\varepsilon \int_0^t r dt - \omega \Delta s\right) r dt.$$

The mass in the column at the time t is

$$m_0 + \omega \Delta s \rho = m_0 \left(1 + \frac{\Delta s}{s_0}\right).$$

Hence by d'Alembert's principle

$$m_0 \left(1 + \frac{\Delta s}{s_0}\right) \frac{d^2 \Delta s}{dt^2} = \left(p\varepsilon v_0 + p\varepsilon^2 v_0 \int_0^t r dt - p\varepsilon\omega \Delta s\right) r - F. \qquad (1)$$

This is the general equation of motion. Its use requires a knowledge of r and F. The only case here considered is that in which r and F are constant. In this case, if we neglect the fraction $\frac{\Delta s}{s_0}$, which may be done for a single or a few pulsations, equation (1) gives the following integral:

$$\Delta s = a \sin(t\sqrt{\beta} + \theta) + \frac{a}{\beta} t + \frac{\gamma}{\beta}, \qquad (2)$$

in which a and θ are the constants of integration, and

$$a = \frac{pv_0\varepsilon^2 r^2}{m_0},$$

$$\beta = \frac{p\varepsilon r \omega}{m_0}, \qquad (3)$$

$$\gamma = \frac{p\varepsilon r v_0 - F}{m_0}.$$

Certain experimental results following the law of equation (2) were cited and explained.

On globular lightning. By Prof. T. C. Mendenhall, Superintendent U. S. Coast and Geodetic Survey, Washington, D. C.

[abstract.]

The paper reviews briefly the evidence for the existence of globular lightning as presented by Arago and others with additional information and quotations drawn from earlier literature. Testimony of recent observers is then related and the conclusion is reached that in view of the mass of evidence, and notwithstanding the conflicting character of much of it, the reality of the phenomenon must be admitted.

The measurement of magnification in the microscope. By Prof. W. LeConte Stevens, Brooklyn, N. Y.

[abstract.]

This paper is a criticism of the rule commonly employed for estimating magnification in the microscope, that of dividing 100 by the product of the nominal focal lengths of objective and eyepiece. The deduction of this

rule is given, and its roughly approximate character is shown in the assumptions it involves.

A method is given and a formula deduced for determining the focal length of the eyepiece and the same is done for the determination of the focal length of an objective without implying any knowledge of the position of its optical centre. Illustrations are given of the application of these methods.

Two independent methods are given for determining the magnifying power of a combination consisting of objective and eyepiece, and the results of the two are compared.

These results are further compared with that obtained by applying the common formula,

$$M = \frac{100}{ff'}$$

and it is shown that under the conditions assumed for its application much more accurate labelling is needed than that usually applied by the makers of these instruments.

RESEARCHES ON SONOROUS SAND IN THE PENINSULA OF SINAI. By Dr. H. CARRINGTON BOLTON, New York, N. Y.

[ABSTRACT.]

THIS paper is in continuation of two others on Musical Sand presented jointly with Dr. Alexis A. Julien at the meetings in Minneapolis and Philadelphia. After alluding to a recent lecture by Mr. Cecil Carus Wilson of England on the singing beach at Bournemouth, the speaker proceeded to narrate his own researches in Arabia Petræa. Leaving New York, January 2, 1889, I reached Cairo January 31st, and in March entered the desert of Sinai; the village of Tor which is the starting point for *Jebel Nagous* is on the Gulf of Suez, but cannot conveniently be visited by water owing to contrary winds. Jebel Nagous is off the regular caravan routes and is not popularly known, hence has been visited but nine or ten times in eighty years by scientific travellers. About four and one-half hours northwest of Tor is the long detached mountain known as Jebel Nagous (or Abu Suweirah). On the steep slopes of this mountain rest several large banks of sand; one of these, which I distinguish by the name Seetzen's Bell Slope, after its discoverer, emits distinct musical sounds whenever the sand slides down the incline either spontaneously or through the agency of man. The mountain consists of massive white sandstone carrying quartz pebbles and veins; it is about three miles long and 1,200 feet high. The huge Bell Slope measures 260 feet across the base, five or six feet across the top and is 390 feet high; it is bounded by nearly vertical walls of sandstone. The yellowish white sand rests on the rocks at the high angle of 31°, is very fine grained, and composed chiefly of quartz and calcareous

sandstone. The grains are well rounded to subangular, and silt is notably absent. As the sand reposes at a high angle it possesses a curious mobility which causes it to flow down the incline like soft pitch or molasses; the sand above the point of disturbance falls into the depression and this depression advances up the slope at the same time. This downward flow takes place spontaneously whenever the sand, forced up the incline by the violent winds, accumulates in such quantity as to exceed the angle of rest. The movement is accompanied by a strong vibration and by a musical tone resembling the lowest bass note of an organ with a tremolo stop. The larger the bulk of sand moved the louder the sound; it is by no means so sensitive as the sand of so-called singing beaches (which I have described elsewhere), and fails to emit sounds when struck with the hand or clapped together in a bag. The vertical cliffs on either side yield an echo that may magnify and prolong the sounds, which were loud enough to be heard several hundred feet. The peak of Jebel Nagous rises above the Slope to the height of 955 feet above the sea level.

The sand of the Slope is derived partly from disintegration of the rock itself and partly from the more distant plain below, from which violent winds blow it up on to the mountain side.

The Bedouins of the region account for the acoustic phenomenon by attributing it to the *Nagous* or wooden gong of a subterranean monastery in the heart of the mountain, and claim the sounds can only be heard at the hours of prayers.

Several other sandbanks presenting a similar appearance to the eye were tested but gave out no musical sounds whatever. Microscopical examination of these sands shows that they contain much silt, which prevents the vibrations necessary to yield the sounds. After careful study, however, of Seetzen's Bell Slope I became convinced that the phenomena could not be unique in the desert as supposed, and I made systematic search for another locality. After testing many sandbanks on the journey northward to Suez I discovered, April 6th, banks of sonorous sand resting on low cliffs a quarter of a mile long. This new locality is in Wadi Werdân about a day and a half from Suez, by camels, and is on hillocks called Ojrat Ramadân.

The sand blown from the extensive plains to the north, falls over the southern face and rests at two angles, 31° at the top and 21° or less near the base. Wherever it possesses the mobility before described it emits a distinct musical note on being disturbed. The highest bank measures only sixty feet on the incline, and it is not probable that the sounds can occur spontaneously. Dr. Julien has named the new locality Bolton's Bell Slope, and reports that microscopical examination shows the sand to consist chiefly of quartz grains, and a larger proportion of calcareous sandstone than at Jebel Nagous. The size of the grains of quartz varies from 0.11 to 0.42 mm. and of sandstone 0.11 to 0.34 mm., the average being smaller than that of the sand grains on Jebel Nagous. Like the latter it is very free from silt.

Various hypotheses have been proposed to explain the cause of the sonorous property in certain sands. Sir James Prinsep, Secretary of the

Asiatic Society of Calcutta, attributes the sound produced at Jebel Nagous to a "reduplication of impulses setting air in vibration in a focus of echo." Hugh Miller, after his visit to the singing beach at Eigg, interested his friend Sir David Brewster in the problem, and he wrote of "accumulated vibrations of the air when struck by the driven sand, or the accumulated sounds occasioned by the mutual impact of the particles against each other." The sonorousness of the sand at Kauai has been attributed to the cellular character of the coralline material, that of Jebel Nagous to its essentially quartzose nature; that of the Baltic coast of Prussia to the saline crust on the beach (Dr. Berendt); but the researches of Dr. Julien and myself show that the sonorous property is independent of material and of saline waters. Many other explanations have been offered which we can here but briefly name: electricity; effervescence of air between moistened grains; solarization; and reverberation within subterranean cavities. Charles Didier, when travelling in Arabia, heard of the acoustic phenomena at Jebel Nagous, and although he did not visit the place promptly offers to explain it by attributing the sounds to "interior cataracts or a subterranean volcano."

Mr. Carus-Wilson, whose paper we have already noticed, explains the sonorousness of sand on a beach as follows: "The music from sand is simply the result of the rubbing together of the surfaces of millions of perfectly clean grains of quartz free from angularities, roughness or adherent matter in the form of clinging fragments investing the grains, and that these microlithic emissions of sound though individually inaudible, might in combination produce a note sufficiently powerful to be sensible to us." (Lecture of Nov. 2, 1888.)

Without attempting to analyze or criticise the above theories, we forthwith give our own, already read to the New York Academy of Sciences on Oct. 15, 1888.

Dr. Julien and I believe the true cause of sonorousness in the sands of singing beaches and of deserts to be connected with thin pellicles or films of air, or of gases thence derived, deposited and condensed upon the surface of the sand grains during gradual evaporation after wetting by the seas, lakes, or by rains. By virtue of these films the sand grains become separated by elastic cushions of condensed gases, capable of considerable vibration, and whose thickness we have approximately determined. The extent of the vibration and the volume and pitch of the sound thereby produced, after any quick disturbance of the sand we also find to be largely dependent upon the forms, structures and surfaces of the sand grains, and especially upon their purity or freedom from fine silt or dust.

Though the environment of the sand on beaches and in the desert differs greatly as respects moisture, we believe that the above theory is applicable to both. Statistics of rainfall in the desert are wanting, but the experiences of travellers and my own observations show that rain falls, in the winter months, abundantly in many parts of the peninsula. In the vicinity of Mount Sinai heavy snows and rain are precipitated in December and January, occasionally causing veritable floods in narrow valleys as

experienced by Captain Palmer. I noted a two hours' shower in Wadi Feiran in March (1889), and I saw raindrop impressions on mudflakes at several points on the coast. Water, therefore, is not wholly lacking to aid in the chemical cleansing of the sand grains, and the powerful winds accomplish the work of sorting and winnowing done by the waves elsewhere. The fineness of the grains at the Bell Slopes makes the displacement of a very large amount of sand necessary for the production of sound, while the coarser particles on the beaches yield a resonance on a smaller provocation.

We have, elsewhere (Proceedings Am. Assoc. Adv. Science, 1883 and 1884) shown that the pitch of the musical notes produced on sea beaches is directly proportional to the mass of sand moved, the greater the mass the lower the tones; on the Bell Slopes in the desert the large mass moved yields a very deep note. [The paper was illustrated by projections of original photographs.]

DETERMINATION OF THE PULSATION PERIOD OF A JENA-GLASS THERMOMETER. By Prof. WM. A. ROGERS, Waterville, Me., aud J. BURKITT WEBB, Hoboken, N. J.

EXPERIMENTAL PROOF OF NEWTON'S LAW OF COOLING. By Prof. WM. A. ROGERS, Waterville, Me.

ADDITIONAL EXPERIMENTAL PROOF OF THE CONSTANCY OF THE RELATIVE COEFFICIENT OF EXPANSION BETWEEN JESSOP'S STEEL AND BRONZE BETWEEN THE LIMITS OF $-5°$ AND $+95°$ FAHR. By Prof. WM. A. ROGERS, Waterville, Me.

THE DETERMINATION OF THE AMOUNT OF RAINFALL. By Prof. CLEVELAND ABBE, U. S. Signal office, Washington, D. C.

EXHIBITION OF A NEW SPECTROSCOPE SLIT. By Dr. ROMYN HITCHCOCK, Washington, D.C.

EXHIBITION OF A THERMOMETER WITH CONSTANT ZERO POINT. By Dr. ROMYN HITCHCOCK, Washington, D. C.

THE HYDRO-ELECTRIC EFFECT OF STRETCHING METALS. By CARL BARUS, U. S. Geological Survey, Washington, D.C.

EFFECTS OF ELECTROSTATIC DISCHARGES ON PHOTOGRAPHIC PLATES. By Prof. THOMAS FRENCH, JR., University of Cincinnati, O.

A MODE OF SUSPENSION FOR FOUCAULT'S PENDULUM. By Prof. R. B. FULTON, University of Mississippi.

AN EXHIBITION OF PHOTOGRAPHS OF THE FUNDUS OF THE EYE OF THE CAT TAKEN WHILE UNDER THE INFLUENCE OF CHLOROFORM. By A. M. ROSEBRUGH, M.D., Toronto, Ont.

EXPERIMENTS IN DUPLEX TELEPHONY IN 1868, A BRIEF ACCOUNT OF THE APPARATUS USED. By A. M. ROSEBRUGH, M.D., Toronto, Can.

A MODIFICATION OF THE PASCAL'S VASE EXPERIMENT. By ALBERT L. AREY, Principal of the Free Academy of Rochester, N. Y.

A MOUNTAIN STUDY OF THE SPECTRUM OF AQUEOUS VAPOR. By Dr. CHAS. S. COOK, Evanston, Ill.

RECENT PROGRESS IN STORAGE BATTERIES. By Prof. GEORGE F. BARKER, Philadelphia, Pa.

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ADDRESS

BY

PROFESSOR WILLIAM L. DUDLEY,

VICE-PRESIDENT, SECTION C.

THE NATURE OF AMALGAMS.

THE subject which I have chosen for my address to you to-day is one which may seem pretentious, considering the state of our knowledge of amalgams. Its announcement may lead you to believe that in discussing it here I propose to settle the questions concerning their constitution and chemistry generally, or at least to present to you some new and startling facts which will do much in that direction. At the outset I desire to relieve you of all such expectations. Our knowledge of the subject is entirely too meager and too scattered to even hope for great advances in a short time, and little more than vague speculation can be indulged in, until careful and systematic study has been given to the individual amalgams.

The work has, thus far, been desultory in the extreme; and though many investigators have begun apparently with much zeal, yet their investigations have been cut short with very little progress reported. Little attempt has been made to continue the lines which have been begun by others, but a few bald and superficial facts have been gathered and thrown recklessly into the storehouse where disorder has complete possession. Why this state of things exists I am sure I cannot say, unless it be that most of our workers fly to fields that will yield the quickest returns; and, as organic chemistry holds out such resistless charms and promises so much numerical wealth for the compound builder upon a small capital, those which will produce a slower growing crop, requiring more labor are passed by and almost wholly neglected.

I have chosen this subject for my address to-day, hoping that as I briefly give the results of some of the most important work that has been done in this rich and unexplored field, some of you may be led into it to reap reward by the discovery of much treasure which is surely there. The beauties do not appear at first on the surface, and it is only after considerable thought and study that the many possibilities and bearings of the work unfold. At first sight it may seem that the labor would consist simply in ascertaining which metals combine with mercury to form amalgams, in determining the composition of the products, and finally in deciding whether or not they are definite chemical compounds. But this is not all. The physical phenomena of their formation are to be investigated as well as their physical and chemical properties; and when this is done and the analogies are drawn and the general laws of their combination formulated, the work is still incomplete, being only introductory to the study of the nature of metallic alloys generally. It will have a most important bearing upon molecular chemistry and physics. It will throw much light on the relative affinities of the atoms and molecules of the metallic elements. Our knowledge of the valence of the metals is derived mostly by comparison through the non-metallic elements. From the formulas of corresponding compounds of the metals with the non-metallic elements we get the comparative affinities of the atoms of the metallic elements, while a careful study of the compounds of mercury with the metals would give a direct comparative value. Who would be led to suppose from the formulas $HgCl_2$ and $AuCl_3$, which show the comparative affinities of mercury and gold for chlorine, that the compound of mercury and gold should indicate the comparative affinity which is represented by the formula Au_8Hg? And so I might enumerate probabilities and possibilities without end, but what has been said will indicate to a slight extent some of the rewards for which we have apparently good reason to hope. They will be attained, however, only by long, patient and careful labor, and after an expenditure of a wealth of ingenuity. He who looks for speedy returns should not enter upon this work for he will meet with discouragement at the very beginning.

The early history of amalgams is exceedingly obscure. The philosopher who first observed and recorded the property which mercury possesses of combining with the other metals is unknown; however, we may conclude that the phenomenon of amalgamation

did not long remain unrecognized after mercury was isolated and came into use, especially as history serves to show that the metals with which it most readily amalgamates were known to the ancients before the discovery of mercury. It appears that gold, silver, copper, tin, lead and iron preceded it chronologically, as neither Moses nor the older Greek writers make any mention of it. Theophrastus[1] (300 B.C.) seems to be the first to mention mercury, and in his work on minerals he gives a method of preparing it from cinnabar; and he calls it "liquid silver."

The first references to the power of mercury to combine with metals are found in much later works. Pliny in the middle of the first century says that "all things float in it except gold and that alone combines with it." Dioscorides in about 100 A.D. in speaking of keeping mercury says "It can only be contained in glass, lead, tin, or silver vessels, as it corrodes and causes other metals to flow away." Isodorus Hispaliensis (about 700) makes similar reference. Juncker[2] (1730) considers that mercury which has been artificially prepared has greater affinity for the metals than the native mercury.

The gold amalgam was the one best known to the ancients and they soon saw the value of mercury for the extraction and purification of that metal. Pliny says the best way to purify gold is to form an amalgam and squeeze out the excess of mercury through skins. He says it flows through "like sweat through the body and leaves pure gold."

Vitruvius gives similar directions for recovering the gold from cloth and clothes embroidered with the metal. He recommends that the garments be burned and the ashes stirred up in a vessel with water and mercury, and that the amalgam be placed in a cloth and squeezed, whereby, he says, "the mercury passes through while the gold, coagulated by the pressure, remains pure within."

Geber[3] (8th century) says "Mercury sticks easily to three minerals, viz., lead, tin and gold; with more difficulty to silver, and with still greater difficulty to copper, but to iron in no manner except through artifice." Paracelsus gives directions for the preparation of copper amalgam by precipitating the copper from the solution of the sulphate by iron, and then mixing it with mercury.

The preparation of an iron amalgam was the cause of much la-

[1] "On Minerals." [2] Conspectus Chemiæ. [3] Summa Perfectionis Magisterii.

bor on the part of the alchemists, and a task which Geber pronounced very difficult. It appears that the first instructions for its preparation were given by Libavius (1606) in the second part of his Commentariorum Alchemiæ in his treatise De Natura Metallorum. He says that metals frequently fail to combine with mercury on account of impurities and that by proper purification he can amalgamate iron. His directions, however, are somewhat obscure. Brandt[1] in 1751 wrote that the iron amalgam could be prepared by rubbing iron with mercury under a solution of ferrous sulphate, but he said the iron very easily separated from the mercury again. Vogel[2] (1789) gave similar instructions advocating the use of alum in place of the ferrous sulphate; while he had already given a method (1783) of preparing it by rubbing zinc amalgam with ferrous sulphate and water.

While it is now well known that the formation of an amalgam is frequently accompanied by a reduction of temperature, the early chemists made the opposite assertion. The first observation of temperature reduction was made by Demachy[3] in 1774, when he found that such was the case in the amalgamation of tin, or the mixing of lead and bismuth amalgams. Little or no investigation was made along this line however until 1860, when J. Regnauld[4] found that heat was absorbed in the amalgamation of zinc and evolved in the amalgamation of cadmium. In a later investigation, Regnauld[5] found that amalgamation caused metals to change their places in the electro-chemical series, and that in combining with mercury, if heat is absorbed the resulting amalgam became more electro-positive than the metal, and if heat is evolved it became less electro-positive. In the first class he placed zinc, lead, tin, iron, nickel and cobalt; and sodium, potassium and cadmium in the second class. Phipson[6] in 1866 found that if 207 parts of lead, 118 of tin and 284 of bismuth are amalgamated with 1617 parts of mercury at 17°, the temperature of the mixture will be reduced to —10°.

Berthelot[7] in 1880 made investigations tending to indicate the constitution of the potassium and sodium amalgams. He examined the chemical constitution of the liquid and solid amalgams of the alkali metals by treating them with dilute hydrochloric acid, meas-

[1] Proc. Stockholm Acad., 1751.
[2] Crell Chem. Ann., 2, 309.
[3] Recueil de dissertations physico-chim., 1774.
[4] Compt. Rend., 51, 778.
[5] Compt. Rend., 52, 533.
[6] Bull. Soc. Chim. (2) 5, 242.
[7] Compt. Rend., 88, 1335. Compt. Rend., 89, 465.

uring the heat disengaged by the reactions and analyzing the solution to determine accurately the quantity of the alkali metals present. From the results obtained he deduced the heats of formation. He found that for one equivalent of potassium, the heat increases with a corresponding decrease in the number of mercury molecules until a maximum is reached, when it begins to decrease. The maximum heat of formation, 34°.2, corresponds with a crystalline amalgam containing 1.6 per cent. of potassium and having the formula $Hg_{12}K$.

As the number of mercury atoms is so large, he considers that some of them may play the same part as that of water in a saline hydrate. He obtained no other crystalline amalgam of potassium, but from his results on the heats of formation he concluded that several others existed.

The heats of formation of the sodium amalgams follow a similar order to those of potassium, giving the formula Hg_6Na for the crystalline compound; and, as in the case of potassium, the existence of other compounds was indicated. He also found that the heat of oxidation of the amalgams rich in potassium exceeds that of those rich in sodium, as do also the heats of formation, and that the relative affinities of the free alkalies in these amalgams are inverted. This, he thinks, serves to explain the apparent anomaly observed by Kraut and Popp,[1] that sodium displaces potassium in a solution of potash when it is treated with sodium amalgam, the final result being the formation of the crystalline amalgam $Hg_{12}K$. In a later research he determined the heats of absorption on dissolving $Hg_{12}K$ and Hg_6Na in different quantities of mercury, and he came to the conclusion that the solution of definite amalgams in different quantities of mercury absorbs a constant amount of heat, like the solution of salts in water. He concluded also that there were two more amalgams of each of the alkali metals in question; and, from experiments in which he observed the quantities of heat evolved upon the progressive addition of the alkali metal, he concluded that one of the potassium amalgams has the formula Hg_4K, while the formula of the one richest in potassium he could not calculate with any degree of accuracy. The two additional sodium amalgams received from him the probable formulas Hg_4Na and Hg_7Na_4.

Calvert and Johnson[2] in 1859 and also in 1864, published some

[1] Ann. Ch. Pharm., 159, 188. [2] Proc. Roy. Soc., 10, 14. Phil. Mag. (4), 18, 541.

of their results on the determination of the heat conductivity of pure mercury and the amalgams. The determinations were confined to the tin, zinc and bismuth amalgams. The tin amalgam proved to be the best conductor, while the bismuth amalgam gave the lowest figure; but in each case the conductivity increased with the decrease in the percentage of mercury in each amalgam.

The electrical conductivity of amalgams has been investigated by Matthiessen and Vogt,[1] Sabine,[2] Weber,[3] and others. Weber's researches were confined to the amalgams of tin, lead, bismuth and cadmium. The results show that the presence of a small quantity of a foreign metal in mercury causes a rapid decrease in the resistance. The conductivity of the amalgam is not the mean conductivity of its constituents. The alloys of mercury with bismuth and lead, however, conduct better than either of their composing metals. The amalgams of the above-named metals form two groups composed of zinc and cadmium, and lead and bismuth respectively. Upon adding zinc or cadmium to mercury the resistance rapidly decreases as the per cent. of the metal increases, and more and more approaches a fixed limit. In the bismuth and lead amalgams the resistance decreases to a minimum and then rises to a maximum. In amalgams and other alloys, points of maxima and minima occur, corresponding to definite chemical combinations.

In 1850 Joule[4] read a paper before the British Association for the Advancement of Science giving an account of his experiments in preparing amalgams electrolytically, by which means he prepared both iron and copper amalgams. He also exhibited a small apparatus whereby he could subject an amalgam to a pressure of sixty tons and thus squeeze out the excess of mercury, leaving an amalgam of approximately definite chemical composition. About ten years later he published[5] his experiments more in detail. He desired to make a perfectly true and polished surface; and to that end he attempted to plate a surface of mercury with iron, supposing that the two metals would not enter into combination. He found however that an amalgam was produced. He then proceeded to prepare the amalgam in order to determine its constitution. He analyzed this, as he did other amalgams which he prepared and studied, "by heating them in a glass tube through which a current

[1] Ann. Phys. Chem. (1), 116, 369.
[2] Phil. Mag. (4), 23, 457.
[3] Ann. Phys. Chem. (2), 31, 243.
[4] Brit. Assoc. Rep., 1850, 55.
[5] Manch. Mem. (3), 2, 115.

of hydrogen was passed." In consequence of the use of this method I may say that his results for the mercury are probably too low. The amalgam of iron containing an excess of mercury was subjected to pressure as high as fifty tons, and an amalgam was obtained, which upon analysis he found contained mercury and iron in the proportion of 100 to 103.2 parts. He also found that iron amalgams, no matter what the proportion of mercury was, exhibited magnetic properties; and he concluded from experiment that iron suffered very little loss of its magnetic virtue by amalgamation. With copper he obtained a beautiful crystalline amalgam by electrolysis, in which he found mercury 100 parts and copper 27.76 parts, having a specific gravity of 13.17. He subjected the copper amalgam to various pressures for different lengths of time, and he tabulates the results of twenty-one experiments and says "On inspecting the above table, it will appear that a moderate pressure continued for a short time leaves a binary compound of the metals along with the quantity of the mercury which may be supposed to be entangled among the crystals. When the pressure was very great, or was continued for a long time, the resulting amalgam invariably contained more than one equivalent of copper. I believe that this arises from a decomposition of the binary amalgam by the violent mechanical means adopted:" He meant by "moderate pressure," from nine to twenty tons, and by "short time," from a "few minutes" to thirty minutes. In these experiments he used pressure as high as one hundred and forty-four tons per square inch for "a few minutes" time.

He prepared a silver amalgam by the action of silver nitrate on mercury, which produced a hard mass of shining crystals to which he gave the formula AgHg. He also found that under a pressure of seventy-two tons the amalgam contained 43.71 of silver to 100 of mercury. Amalgams of platinum, zinc, lead and tin were also prepared. He concluded from the specific gravities of the various amalgams that considerable contraction in volume took place in the formation of the copper, silver and zinc amalgams, and little or none in platinum and lead.

Joule made an unsuccessful attempt to amalgamate hydrogen by developing it at a low temperature (0°.F) on mercury. He considered however that the experiment was worth repeating and thought that at a very low temperature and high pressure such an amalgam might be obtained.

In the conclusion of his last paper he says, "As metals generally retain their specific gravities when they meet to form alloys, it may be inferred that the foregoing experiments indicate the specific gravity of mercury in the solid state. This value from the average of thirty-six determinations of specific gravity above given, is 15.19." The value he obtained from the copper amalgams was 14.985, while the latest determinations of solidified mercury put the specific gravity at 14.931.

Henry[1] found that if finely divided gold was treated with mercury and the excess of the latter removed by pressing it through chamois leather, the residue upon treatment with hot nitric acid would, after all of the free mercury had been dissolved, leave yellow shining crystals having the formula Au_8Hg. These crystals are not decomposed by boiling in hot concentrated nitric acid. If an amalgam containing about five per cent. of gold is heated for several days to about 80° and then treated with hot nitric acid, a mass of crystals of considerable length may be obtained. By this means I have obtained needles as long as 1.5 cm.

De Souza,[2] in 1875, began to study the effect of constant temperatures on some amalgams. He heated silver amalgam in the vapor of boiling sulphur until it no longer lost weight, and upon analysis the compound was found to be represented by $Ag_{13}Hg$. Gold amalgam under similar treatment possessed the formula Au_9Hg. In 1876,[3] he repeated his former experiments, verifying the results then obtained. He also heated the amalgams in atmospheres of boiling mercury and diphenylamine. Gold amalgam at the temperature of boiling mercury had the formula Au_9Hg; while in the vapor of diphenylamine less mercury was driven off, and the formula was found to be Au_8Hg. Silver amalgam was represented by $Ag_{11}Hg$ in mercury vapor, and Ag_4Hg in diphenylamine. Copper amalgam was found to possess the formula $Cu_{16}Hg$ in the vapor of boiling sulphur, $Cu_{14}Hg$ in the vapor of boiling mercury and the same in diphenylamine. Potassium amalgam was represented by K_2Hg in the vapor of boiling sulphur; sodium amalgam Na_3Hg after similar treatment, and lead analgam $Pb_8 Hg$, heated to the temperature of boiling mercury. Later, Merz and Weith[4] repeated De Souza's experiments, modifying his methods to some extent; but their results were by no means confirmatory. They exposed amal-

[1] Phil. Mag. (4), 9, 468.
[2] Ber. Deut. Chem. Ges., 8, 1616.
[3] Ber. Deut. Chem. Ges., 9, 1050.
[4] Ber. Deut. Chem. Ges., 14, 1438.

gams of gold, silver, copper, lead, tin, bismuth, zinc, cadmium, sodium and potassium to temperatures of boiling sulphur, boiling mercury and boiling diphenylamine for several hours, and found in every instance that the mercury was almost, if not wholly expelled, the amalgam having been decomposed. In each case they began the heating upon the amalgam containing from sixty to eighty per cent of mercury and continued it until there was practically no longer any loss of weight. The amalgam of sodium and potassium parted with the mercury slowly; the latter, however, more easily than the former. A stream of an indifferent gas was passed over the amalgam during heating. In the case of the alkalies, the investigators generally employed hydrogen, but sometimes nitrogen, fearing that the hydrogen might possibly combine with the alkali in the amalgam. They found, however, that such was not the case, at least the combination was only momentary and upon analysis an appreciable amount of hydrogen was not recognized; and yet it was found that the mercury was more rapidly given off in a current of hydrogen than in nitrogen. As the result of their work they concluded: (1) that amalgams under a moderate heat undergo decomposition; (2) that gold and other amalgams lose almost all, if not all, of their mercury at the boiling point of mercury; (3) that the small amount of mercury retained is due to mechanical attraction and not to chemical affinity; (4) the fact that mercury can be pressed out of many amalgams indicates that they are molecular compounds; (5) that of the metals, sodium and potassium have the strongest affinity for mercury.

It would seem from the description of the apparatus which they used, that the temperatures to which the amalgams were subjected were considerably higher than should have been obtained in the vapors of the boiling substances employed, for the reason: (1) that the apparatus was too small; (2) the tube containing the amalgam was too near the boiling substance; and (3) if the description of the apparatus be understood, the substance must have been boiling under more or less pressure.

I have repeated the experiment of De Souza upon the gold amalgam in an apparatus of my own design and at the temperature of boiling mercury. The amalgam after arriving at constant weight was represented by the formula Au_9Hg, which is the same as that he obtained. This result has also been verified by Schnauss.[1] I have

[1] Arch. Pharm. (3), 6, 411.

not had the opportunity, however, of heating the amalgam in a stream of hydrogen or nitrogen as did Merz and Weith, so that I cannot pass final judgment upon the cause of the discrepancy in their results; but from the statement that they make, *i. e.*, that in the case of sodium and potassium amalgams, the mercury is more rapidly expelled in a current of hydrogen than in a current of nitrogen, I may be justified in asking if the passage of even hydrogen or nitrogen over the amalgams may not cause their decomposition? These gases, usually so indifferent, may not be so in this case. There may exist some affinity on the part of the hydrogen or the nitrogen for the mercury or the metal associated with it, which, though very feeble, is sufficiently strong when assisted by heat to overbalance the weak affinities in the amalgams.

Merz and Weith also obtained some interesting results on the melting points of the amalgams of sodium and potassium, and they conclude that the melting point bears no relation to the percentage of the alkali metal in the amalgam. It was frequently found that part of the amalgam would melt first, the portion remaining having a higher melting point. A sodium amalgam, containing 3 per cent. of sodium, melted at 152°–160°; with 4.7 per cent. of sodium the amalgam melted at 305°–315° which was the maximum, and as the proportion of sodium increased the melting point decreased; and finally, an amalgam containing 37.9 per cent. of sodium melted at about the same temperature (152°–159°) as that containing 3 per cent. With the potassium amalgam similar phenomena were observed; that containing 2.7 per cent. of the alkali metal melted at 75°, and the melting point increased with the amount of potassium up to 9.8 per cent. when it was observed to be 240°–245°; it then became lower as the percentage of the potassium increased, and with 29.8 per cent. it melted at 147°–152°. If 4 to 5 per cent. of sodium be added to mercury heated to 250° under paraffin, a solid amalgam will result, but with the addition of a few per cent. more of sodium the whole mass will become liquid, and if mercury is then added, it will again become solid. Potassium under similar conditions will act in a similar manner.

Wanklyn and Chapman,[1] in 1866, succeeded in producing a magnesium amalgam, by heating the metal with mercury nearly to the boiling point of the latter. Under these circumstances the combination took place with considerable violence, while a piece of po-

[1] Jour. Chem. Soc., 19, 141.

ished magnesium combined with mercury, slowly in the cold. On exposure to the air they found that the magnesium in the amalgam would oxidize rapidly, the mass swelling up and becoming quite hot if moistened with water. It decomposed water violently when immersed in it. These facts are interesting, as it will be noticed that the chemical activity of magnesium is increased by amalgamation, while that of sodium and potassium is much diminished. In this respect aluminum seems to behave like magnesium, for according to Casamajor[1] who prepared the aluminum amalgam by placing aluminum and a zinc rod in contact with mercury and covering them with acidulated water, the aluminum amalgam when dry became quite hot, the mercury appearing to boil, and the surface becoming rapidly coated with a white incrustation of aluminum oxide.

The constitution of ammonium amalgam was, for a time, much discussed and many opposing views were held. It was discovered about the same time by Seebeck[2], and Berzelius and Pontin.[3] Wetherill[4] supposed that when sodium amalgam acted upon a solution of ammonium chloride, the sodium first acted on the water, evolving hydrogen and forming sodium hydroxide, which would in turn set ammonia free, and that the molecules of hydrogen and ammonia thus liberated would, by some means, be retained in the mercury and form a spongy mass. During the winter of 1863–4, in the laboratory of the Smithsonian Institution, he proceeded to prove his hypothesis by experiment. He found that the hydrogen evolved by sodium amalgam in hydrochloric or sulphuric acids and also in potassium hydroxide solution would not cause the mercury to swell; but that this phenomenon would immediately take place upon the addition of a small quantity of ammonium chloride. He also found that hydrogen developed by sodium amalgam in a solution of ammonia would not produce turgescence. Hence, he concluded that both the hydrogen and ammonia should be in a nascent state. The ammonium amalgam was obtained by him from solutions of the chloride, oxalate, carbonate, sulphate and bisulphate, but he could not obtain it from the nitrate, even by the aid of electrolysis. He subjected the amalgam to pressure between two glass plates and obtained a reticulated film owing to the bubbles of the escaping gases from the constantly decomposing amalgam, and from this he

[1] Amer. Chemist, 6, 450.
[2] Gilbert's Ann., 6, 260.
[3] Gehlen neu. Allg. Jr. Ch., 5, 482.
[4] Sill. Amer. Jour. (2), 40, 160.

drew the conclusion, that the so-called amalgam was merely mercury with these gases incorporated. From these and some other experiments, he concludes: (1) "the so-called ammonium amalgam is not an alloy of mercury and ammonium; (2) the swelling of the mass in the phenomenon is due to the retention of the gas bubbles, and (3) the coherence of the gases and liquids concerned is changed from the normal condition, exhibiting phenomena which may be classed with those of catalysis."

Pfeil and Leffman[1] treated a saturated solution of the hydrochloride of trimethylamine with sodium amalgam and obtained phenomena similar to those which occur in the preparation of ammonium amalgam. The turgescence, however, rapidly subsided, hydrogen being given off, and trimethylamine was contained in the liquid. Wetherill[2] had previously recorded a similar result with the oxalate of methylamine. Pfeil and Leffman treated solutions of aniline, conine, morphine and quinine hydrochlorides and also the acetate of rosaniline with sodium amalgam and no turgescence was observed, although hydrogen was copiously evolved. They also found that when a solution of ammonium chloride in pure glycerine was treated with sodium amalgam, ammonium amalgam was formed, but the swelling of the mass was interfered with, and that if sodium amalgam be brought in contact with a crystal of ammonium chloride, no action ensued until it was moistened with water. The authors considered that the results which they obtained coincided with those of Wetherill and afforded additional evidence that the ammonium group does not alloy with mercury.

Seely[3] considered the ammonium amalgam a mechanical mixture of ammonia and hydrogen in mercury for the following reasons: (1) that the volume of the ammonium amalgam cannot be explained in any other way; (2) that no solid or liquid chemical compound nor any amalgam is analogous to it. He says "mercury has a polished surface while the ammonium amalgam possesses a duller and whiter appearance, like unpolished silver." "It is like a foam and if subjected to varying pressure the volume changes with it and evidently according to Mariotte's law;" this he attempted to prove, in a very crude way, by subjecting the amalgam to pressure in a tube fitted with a piston, when he found that it was condensed to the original volume of the mercury, taking on the appearance of

[1] Sill. Amer. Jour. (2), 42, 72.
[2] Sill. Amer. Jour. (2), 40, 160.
[3] Chem. News, 21, 265.

that metal, and on relieving the pressure it returned to the original bulk. He finally came to this unique conclusion, viz., that ammonium is not a metal, and that if the monovalent radical does exist, it is not a solid nor a liquid but a gas.

It is unnecessary to comment upon the weak points in the researches upon the nature of the ammonium amalgam which I have just outlined, nor is it worth while to pause longer upon their conclusions, as they have only an historical interest.

Davy[1] analyzed the gases evolved by decomposing ammonium amalgam and found them to consist of hydrogen and ammonia in the proportion of one volume to two, while Gay-Lussac and Thénard[2] obtained from the amalgam prepared by electrolysis twenty-three volumes of hydrogen to twenty-eight volumes of ammonia; and from that prepared by means of potassium amalgam, 1 volume of hydrogen to 2.5 volumes of ammonia. These conflicting results led Landolt[3] in 1868 to redetermine the proportion of the gases evolved, and the result he obtained was 1 volume of hydrogen to 2.15 volumes of ammonia. His results, which agree fairly well with Davy's, led him to believe that the ammonia and hydrogen are combined with the mercury in the proportion required to constitute ammonium, and therefore that the ammonium amalgam is the result of a chemical union between ammonium and mercury. He also found that the proportion by weight of mercury to ammonium, in a saturated amalgam, was 106 parts of mercury to .09 parts of ammonium. Landolt also endeavored to determine whether the ammonium group possessed metallic properties. He argued as sodium and potassium amalgams, if thrown into solutions of many metallic salts, would be decomposed, the metal precipitated and an amalgam be formed, that the ammonium amalgam should exhibit the same behavior. He found that it would not precipitate the metals as did sodium and potassium amalgams. He rightly concluded, however, that this did not prove the non-existence of a true ammonium amalgam, but simply showed that the ammonium, when set[4] free, was decomposed into ammonia and hydrogen. Routledge, in 1872, redetermined the comparative volumes of ammonia and hydrogen in the gases evolved from ammonium amalgam, as he had come to the conclusion that Landolt's results were inaccurate on account of the manipulation to which the latter subjected the amal-

[1] Phil. Trans., 1808, 353; 1810, 55.
[2] Rec. Physico-Chim., 1, 63.
[3] Ann. Chem. Pharm. Sup., 6, 346.
[4] Chem. News, 26, 210.

gam. He obtained the following result: 1 volume of hydrogen to 1.97 volumes of ammonia, substantially confirming those of Davy and Landolt. He also determined the change of volume of the amalgam, which took place under different pressures, and concluded that the compressibility of the amalgam results from the pressure of free gases, due to its decomposition. Thus it appears that the question as to whether or not the ammonium amalgam is a chemical compound of the radical ammonium and mercury, is definitely settled in the affirmative. There seems to be as good reasons for the existence of a compound of ammonium and mercury, as for those of the well known compounds of mercury with the various alcohol radicals.

Several attempts have been made to prepare an amalgam of hydrogen and mercury; that made by Joule having already been referred to. Döbereiner[1] and Loew[2] claim to have prepared it. The latter found that when zinc amalgam was shaken with water, a slow decomposition took place, and flocculi of zinc hydrate were formed, with the evolution of hydrogen. The decomposition was hastened if a small quantity of platinic chloride was added,—and at the same time a substance was formed on the surface of the undecomposed zinc amalgam, which he supposed to be an alloy of hydrogenium and mercury. To obtain it on a larger scale he took an amalgam containing five per cent. of zinc and warmed it until it fused, and then shook it up with an equal volume of a ten per cent. solution of platinic chloride, taking care to keep the mixture cool. The zinc amalgam swelled up considerably, and continued to evolve hydrogen until it was entirely decomposed. The hydrogenium amalgam thus prepared was pressed between sheets of filtering paper. When spread out in a layer (not too thin) in the air, the temperature soon rose considerably and the vapor of water was formed, which was condensed in a glass receiver. He considers that the finely divided platinum present in the amalgam was the cause of this rapid oxidation of the hydrogen. He says further that by the action of the platinic chloride on the zinc amalgam the oxychloride of zinc is produced, which may be removed by hydrochloric acid but greatly at the expense of the hydrogenium amalgam, and if washed with water the remainder undergoes slow decomposition with increase in volume. He thinks that the presence of zinc amal-

[1] Thomson's Annals, 6, 224; 7, 80. [2] Sill. Amer. Jour. (2), 50, 99.

gam, and also of sodium amalgam, greatly accelerates the decomposition. From these results Loew draws the conclusion, strangely enough, that hydrogenium is analogous to ozone, and consequently, that it may be represented by the formula H_3 as ozone is represented by O_3, instead of inferring what seems to be more natural, viz., that hydrogenium behaves like a metal.

Regnauld found that the specific heat of an alloy is equal to the mean of the specific heats of its components. Exceptions to this rule exist in certain bismuth, tin and lead alloys, and Spring has since shown that certain cadmium, tin, lead and bismuth alloys and amalgams also, do not conform to the above rule. In the case of the alloys, Wiedemann[1] thinks that these differences may probably be explained by the occurrence of molecular changes accompanied by the evolution of heat, while in that of amalgams it would appear that they are a mixture of a solid and a fluid, the proportions of which vary with the temperature. To prove this, two amalgams, SnHg and Sn_2Hg, were examined with tin as a comparison, at high temperatures. Both amalgams cooled nearly as rapidly as the tin, showing the specific heats of the tin and the two amalgams to be nearly the same, which would be the case according to Regnauld's law. The SnHg and Sn_2Hg, at 128° and 164° respectively, behaved in the same manner as the lead alloys in the neighborhood of their so-called second melting point; but the temperature did not appear to remain constant at a fixed point for any length of time, as it did for seven minutes in the case of the tin-lead alloy. The so-called second melting-point Wiedemann considered to be the temperature at which the metal dissolved in the alloy begins to be deposited on cooling; but it seems to me that the metal itself would not be deposited, but a richer alloy would separate, or crystallize out, from the molten mass. I have previously referred to the fact noticed by Merz and Weith, that in fusing sodium and potassium amalgams a portion melts first and finally the remainder becomes fluid.

From the résumé of the more important researches on the nature of amalgams which I have briefly outlined, it seems to be proved that amalgams are chemical compounds, more or less unstable. The fact that heat is absorbed in the amalgamation of a metal, does not argue against the chemical nature of the resulting combination,

[1] Ann. Phys. Chem. (3), 3, 237.

for the excess of mercury, dissolving the amalgam as it forms, absorbs more heat than is produced in its formation.

In the presence of an excess of mercury, the nature of the resulting mixture is not so well understood, although many facts are known which seem to indicate that the amalgam dissolves in the mercury to a certain extent. The fact that a large part of the amalgam may be separated from the excess of mercury by straining it through chamois leather, or other porous material, certainly indicates that the portion so removed is not in solution. I have found that if mercury containing 0.1 per cent. of gold be placed in a tall cylinder and allowed to stand quietly for several months, a portion of the gold amalgam will settle to the bottom, as an analysis of the mercury taken from the top showed that it contained only 0.0683 per cent. of gold. The temperature during the time of settling averaged about 20°C. Thinking that even this small quantity of gold might be some of the definite amalgam in suspension and not in true solution, I filtered some of it through boxwood and on analyzing the mercury thus filtered I found it to contain 0.0601 per cent. of gold. This seems to indicate that mercury will dissolve only about 0.06 per cent. of gold at 20°C., and that a greater amount than this in mercury at that temperature is the definite amalgam in suspension.

The definite amalgams are, as far as they are known, crystalline in structure, and it may be that instead of dissolving in mercury as a salt does in water, *i. e.*, breaking down to the molecule, the mercury disintegrates the amalgam to nothing smaller than the crystal unit, so that when the mercury is squeezed through chamois leather the crystal units which have collected together in masses of sufficient size cannot pass through the pores of the skin, while the smaller masses and the single crystal particles are not held back; but if the mercury be forced through boxwood or material having smaller pores, more of the amalgam refuses to pass through.

I append hereto an index to the literature pertaining to the subject, and although it may not be complete, I can say that I have endeavored to make it so. I give first a list of the more important references (with the titles) which deal with the subject in a more or less general way. Under the respective metals will be found the references which relate to them specially.

INDEX TO LITERATURE ON AMALGAMS.

I. General.

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PAPERS READ.

ESTIMATION OF BROMINE IN PRESENCE OF CHLORINE. By Prof. A. B. PRESCOTT and W. L. DUNN, Ann Arbor, Mich.

FOR estimation of bromides taken in mixture with chlorides indirect methods of analysis have been, until within about ten years, almost the only trustworthy dependence. The reactions used for actual quantitative separation did not go further than removal of an excess of the chlorides to obtain a concentration of the bromides preparatory to their final estimation. In late years, however, trial has been made of certain reactions for complete separation, in methods of direct analysis, and it can no longer be said that every direct method is unsafe. Seeking, first, the best of the known methods for indirect estimation, and then the best of the proposed methods for direct estimation, the writers have undertaken a set of control analyses with each method so adopted, and the results are given below.

I. For an *indirect estimation*, starting with a weighed quantity of silver bromide and chloride, as the one factor, it was decided to take metallic silver as the other required factor. The reduction to metallic silver was adopted, after collating the authorities, as capable of closer results than those obtained by conversion of the mixed bromide and chloride to entire chloride of silver according to Wittstein[1] and others; or conversion to entire bromide of silver by digesting with potassium bromide solution according to Field,[2] Siewart,[3] or Huschke,[4] these methods providing for estimation of iodide as well. The conversion first to bromide and then to the iodide, by intervention of cyanide solution, after Maxwell-Lyte,[5] though favorably reported upon by Whitfield,[6] is certainly more complex than conversion to metallic silver. The reduction of the silver haloids by heating in a stream of hydrogen, according to the earlier directions of Fresenius, was never wholly satisfactory, and may well be superseded by electrolytic reduction. At an early period the electrolysis of the fused mass was proposed by Bolley.[7] Careful control analyses were made, a few years ago, by Kinnicutt,[8] who applied the poles to the fused mass covered with dilute sulphuric acid. A more favorable condition for the electrolysis is that of the cyanide solution of the silver haloids,[9] a solution obtained directly from

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[3] M. SIEWART, 1868: *Zeitsch. anal. Chem.*, **7**, 469.

[4] OTTO HUSCHKE, 1868: *Zeitsch. anal. Chem.*, **7**, 434.

[5] MAXWELL-LYTE, 1884: *Chemical News*, **49**, 3; *Am. Chem. Jour.*, **6**, 352.

[6] *Am. Chem. Jour.*, **8**, 425.

[7] BOLLEY, 1859: *Ding. polyt. Jour.*, **151**, 46.

[8] L. P. KINNICUTT, 1882: *Am. Chem. Jour.*, **4**, 22; *Jour. Chem. Soc.*, **42**, 722.

[9] LUCKOW, 1865: *Ding. polyt. Jour.*, **178**, 43.

the argentic precipitate, whereby fusion and its disadvantages are avoided. Mr. Whitfield of the U. S. Geological Survey has recently subjected the plan to a careful trial, and with his report[1] has given a good account of methods hitherto in use. He found good results by the deposition of metallic silver from the cyanide solution; also good results by the precipitation of silver iodide from the same solution. And the directions given by Whitfield[2] were taken as an outline of the operation for indirect analyses, in this work, the operation being finally adjusted as follows.

Of the mixed chloride and bromide, five grams were taken. The complete silver precipitate, obtained as required in gravimetric work and carefully protected from the light, was filtered through a weighed asbestos filter. The filter found best for this purpose is prepared as follows: A carbon-tube[3] is selected, a light plug of absorbent cotton is placed in the bottom, and then a layer of very thoroughly washed asbestos about one-fourth of an inch in thickness. The filter was dried, to a constant weight, in an air-bath at 150°C., cooling in a desiccator. The precipitate well washed on this filter was dried at same temperature in the same bath and weighed under equal conditions, to obtain the weight of the silver chloride and silver bromide. The precipitate is then dissolved on the filter by application of potassium cyanide solution, using least possible quantity of the solvent, while completely washing out the solution into a weighed platinum dish, which is in contact with the negative pole of a battery of two Bunsen cells. The positive electrode is introduced into the solution, but not brought in contact with the dish. The current is continued until the solution is destitute of silver, as shown by a drop of the solution taken upon a glass slide, over a dark ground, remaining entirely clear while treated with a drop of hydrochloric acid. As soon as the silver is completely deposited, the dish is removed from the battery, drained and several times washed with water, to prevent the solvent action of the cyanide upon the metallic silver. The dish with the silver deposit is dried in the air-bath, cooled and weighed. For both weighings of the dish its temperature is equalized in the balance-case.

The results of *seven* control analyses by this method, in the indirect way, are given further on.

II. For a *direct estimation*, the separation of the bromine by the action of chromic acid, in distillation, was adopted. The reactions of chromic acid with chlorides, bromides and iodides, under specific conditions, have been reported upon[4] for many years. Adaptation to the quantitative separation of the haloids was made by Dechan in 1886,[5] who sets forth what was partly shown by Donath, that having dichromate in proper concentra-

1 J. EDWARD WHITFIELD, 1886: *Am. Chem. Jour.*, 8, 421; *Jour. Chem. Soc.*, 52, 525.

2 Where last cited.

3 In the form of a test-tube of full width, perforated on the bottom, where a section of glass-tubing is fused on, over the perforations, serving as a funnel-neck.

4 WOHLER, 1834: *Ann. Phys. Chem. Pogg.*, 33, 343.
DONATH, 1880: *Zeitsch. anal. Chem.*, 19, 20.

5 M. DECHAN, 1886: *Jour. Chem. Soc.* (Trans.) 49, 682.

tion, on boiling, iodine is liberated from iodides and distilled over in complete separation from bromine. Then, on adding sulphuric acid in due quantity, and maintaining a certain concentration, bromine is all distilled over while all chlorine is left behind, greater concentration being required to distil any chlorochromic anhydride. As finally adjusted in this experimentation, the process is as follows:

A distilling flask of fully 150 c.c. capacity admits a separatory funnel, closed with a stop-cock, the funnel-tube reaching the bottom of the flask. The vapor-tube of the distilling flask, bent just above the stopper to a line slightly descending for four or five inches and then turned down vertically, forms the inner tube of an upright Liebig's condenser of about eight inches length, when it passes to the bottom of a receiving flask of about 100 c.c. capacity and with twice tubulated stopper, the second tubule connecting with an aspirator. The distilling flask is adjusted on a retort-stand over a small Bunsen burner directly applied. Of potassium dichromate fifty grams are placed in the distilling flask, and 100 c.c. of distilled water are added, with 0.5 to 1.0 gram of the haloids, the material in which the bromine is to be estimated. With very low percentages of bromine there may be taken 2.0 grams of the material. The distilling flask being in position, connected with the vapor tube and the receiving flask, heat is applied until the dichromate is all dissolved. If iodine be present, the distilling liquid is boiled, with the aspirator in action and the funnel-tube open, until the distillate ceases to turn starch water blue, when, if desired, the iodine can be estimated as directed below for bromine. The receiving flask is now cleaned and charged with 10 c.c. of thirtieth normal solution of arsenious acid; the distilling flask is charged with 10 c.c. of sulphuric acid previously diluted to 20 c.c.; and the distilling liquid is boiled, while the aspirator is in action, the funnel-tube open, and the condenser kept cold. The contents of the distilling flask are maintained at a volume of 100 to 120 c.c. After boiling about an hour, the flame is removed, the receiving flask detached, with rinsing of the delivery tube, a test-tube containing some drops of potassium iodide solution and starch water placed as a receiver, and the flame replaced until the distillate is tested for absence of bromine. When the distillation is complete, the contents of the receiving flask are titrated with thirtieth normal solution of iodine, this solution having been compared with that of arsenious acid. The quantity of iodine used is calculated into its equivalent of bromine.

Other methods of direct estimation depending upon the action of oxidizing agents other than chromic acid, upon the graded differentiation of the haloids, are methods[1] with permanganate, manganese dioxide and

[1] MOHR, manganese dioxide, 1855: *Ann. Chem. Phar.*, **93**, 80.
VORTMANN, manganese and lead dioxides, 1880: *Ber. d. chem. Gess.*, **19**, 352.
BERGLUND, Vortmann's method, 1885: *Zeitsch. anal. Chem.*, **24**, 196.
BERGLUND, use of permanganate, 1885: *Zeitsch. anal. Chem.*, **24**, 184.
E. HART, permanganate in qual. anal., 1885: *Zeitsch. anal. Chem.*, **24**, 182.
CAZAZZI, on barium dioxide, 1886: *Gaz. Chim. ital.*, **13**, 174.
COOK. use of hydrogen peroxide. 1885: *Jour. Chem. Soc.*, **47**, 472.
SCHOENE, the same, 1879: *Ann. Chem. Phar.*, **195**, 228.

hydrogen peroxide. Such a partial separation of the haloids, as has been found serviceable for concentration of bromine, is effected by fractional precipitation with the silver,[1] by solubility of alkali[2] salts in alcohol, and by the manganese dioxide as above.[3]

I. BY INDIRECT METHOD.

	NaCl taken.	KBr taken.	Br taken.	Br found.	Error.	Error per 1 of material.
1	5.000	0.020	0.01343	0.013320	0.000110	0.000022
2	5.000	0.010	0.006715	0 006500	0.000215	0.000043
3	5.000	0.010	0.006715	0.005920	0.000795	0.000156
4	5.000	0.0082	0.005506	0.005405	0.000101	0.000020
5	5.000	0.0062	0.004163	0.003020	0.001143	0.000228
6	5.000	0.0100	0.006715	0.006620	0.000095	0.000019

II. BY DIRECT METHOD.

	NaCl taken.	KBr taken.	Br taken.	Br. found.	Error.	Error per 1 of material.
1	0.480	0.020	0.013431	0.013559	0.000128	0.000256
2	0.480*	0.020	0.013431	0.012862	0.000569	0 001138
3	0.563	0.010	0.006715	0.005583	0.001132	0.001971
4	0.483	0.010	0.006715	0.006431	0.000284	0.000573
5	0.400†	0.010	0.006715	0.006640	0.000341	0.000183
6	0.485	0.015	0.010072	0.009910	0.000162	0.000324
7	0.490	0.010	0.006715	0.006581	0.000134	0.000268

* Of sodium chloride and magnesium sulphate.
† Of sodium and calcium chlorides and sulphates.

In the first four experiments by the direct method, dicinormal solutions of arsenious acid and of iodine were used. The more dilute solutions, thirtieth normal, gave better results.

MOLUGRAMS AND MOLUGRAM-LITRES. By Prof. CHARLES E. MUNROE, Newport, R. I.

[ABSTRACT.]

THE term molugram is proposed for use to designate the number of grams-mass of a substance that is numerically equal to the molecular-mass of this substance referred to its unit. Thus, taking hydrogen as the stand-

[1] FEHLING, 1848: *Jour. prakt. Chem.*, 45, 269.
[2] MARCHAND, 1849: *Jour. prakt. Chem.*, 47, 363.
[3] See note on previous page.

ard of molecular-mass, one molugram of hydrogen equals 2 grams; of oxygen 32 grams; of water 18 grams; of mercury 200 grams, etc. This quantity is generally referred to as the molecular weight of a substance taken in grams, but this method of statement is both awkward and incorrect. The values attached to this term are, however, often very convenient, and I feel that its use will be less confusing if designated by some such term as the above.

The term molugram-litres is proposed for use to designate the volume in litres at 0°C. and 76 cm. of pressure, when in the state of a gas, of the number of grams-mass of a substance that is numerically equal to the molecular-mass of this substance referred to its unit. This value, which is constant for all substances, is 22.32 litres, and it is a most convenient one for use in stochiometrical calculation. By the adoption of this term molugram-litres to designate this value, we may avoid circumlocution while we gain in precision of statement.

THE EXPLOSIVENESS OF THE CELLULOIDS. By Prof. CHAS. E. MUNROE, Newport, R. I.

[ABSTRACT.]

BY celluloids we mean the bodies produced by the action of camphor on the lower cellulose nitrates and which become plastic, so as to be readily molded, when heated to a moderately high temperature. Two varieties are used in the arts, a translucent one and an opaque; the latter being formed by the admixture of zinc oxide and other incombustible, inexplosive materials with the translucent variety, while the translucent variety consists simply of pyroxylin and camphor with various coloring matters, principally of organic origin. The opaque variety is the one which is most largely used in the manufacture of articles for the toilet, wearing apparel, pianoforte keys and the like. Owing to the presence of pyroxylin in these bodies, there is a popular belief that they are explosive, but this is denied by the manufacturers. The books show that similar differences of opinion exist among the writers on this subject.

In this paper are given the results of experiments made for the purpose of testing the "stability," flashing point and explosiveness of the two varieties and the results show that the opaque variety is insensitive to the shock of detonators at ordinary temperatures but that the translucent variety is readily exploded by this means.

A NEW BOTTLE FOR HYDROFLUORIC ACID. By Prof. EDWARD HART, Easton, Pa.

[ABSTRACT.]

THE bottle is a hollow casting made of wax, paraffine, or cerasine, or a mixture of these substances. Cerasine is preferred because of its higher melting point. The stopper is inverted and the mushroom top melted to

the rim during transportation. When received it is cut apart with a penknife and inverted.

An approximate table of the relations between the specific gravity and percentage composition of aqueous hydrofluoric acid is also given.

[This paper will appear in the Journal of Analytical Chemistry.]

THE CHEMICAL CONSTITUTION OF THE MICA GROUP. By Prof. F. W. CLARKE, Washington, D. C.

[ABSTRACT.]

THE author discusses the chemical structure of the micas, chlorites, vermiculites, etc., and shows that all these compounds are reducible to one general type of formula, under which they become substitution derivatives of aluminum orthosilicate.

FOOD PREPARATION. By Dr. FRED. HOFFMANN, New York, N. Y.

[ABSTRACT.]

ACCORDING to reliable estimates the quantity of artificially manufactured foods used for infants and children amounts in the United States in money value to nearly ten million of dollars.

Whilst the supply and the quality of food are controlled by legal regulations in all civilized nations, there is no such control of the food supply for infants and invalids, as soon as this food is artificially prepared. As these foods are of uncertain composition and quality and to a large extent perhaps prepared without due consideration of correct physiological and chemical principles, there is hardly any doubt that the deficient quality of such commercial infants' food has a far greater influence upon the unusually large mortality rates of infants in our large cities than is generally suspected.

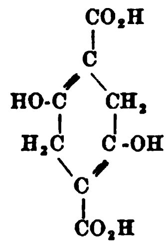
In presenting a printed list of analytical results of such much-used foods as have been analyzed, I simply will call the attention of chemists to this very important matter which deserves a much wider investigation.

SUCCINYLO-SUCCINNIC ACID. By Prof. ADOLPH BAEYER, Munich, Germany, and Prof. W. A. NOYES, Terre Haute, Ind.

[ABSTRACT.]

SOME time since one of us showed that the ethyl ester of dioxyterephthalic acid could be reduced to the ester of succinylo-succinnic acid. Dioxyterephthalic acid had not, hitherto, been reduced. It has been found that the reduction can be easily effected by means of sodium amalgam. In this way succinylo-succinnic acid has been obtained in larger quantities than before and more carefully studied. The acid is very difficultly soluble in

water, requiring more than five thousand parts at 20°. This gives some ground for believing the structure to be that of a $\Delta^{1,4}$ dioxydihydroterephthalic acid.



The ease with which the acid loses carbon dioxide and gives tetrahydrochinone, and the ease with which it reacts with phenyl-hydrazine point, however, to the ketone formula. From tetrahydrochinone (hexamethylene diketone) the dioxime was prepared and from this, by reduction with sodium and alcohol, hexamethylene diamine was obtained. This shows the remarkable stability of what Bamberger calls the alicyclic bases.

The hydrazone of the di-ketone was also prepared and this by reduction gave, probably, *two* hydrazo compounds which appear to be "geometric" isomers. The hydrazone, unlike any hitherto known, shows basic properties, forming weak salts.

ON THE ACQUISITION OF ATMOSPHERIC NITROGEN BY PLANTS. By Prof. W. O. ATWATER, Middletown, Conn.

[ABSTRACT.]

EXPERIMENTS, similar to those reported at the Philadelphia meeting of the Association and described in detail in Vol. IX of the American Chemical Journal, confirm the results of those experiments and of later ones by Hellriegel and others in indicating that some leguminous plants, at any rate, acquire large quantities of nitrogen from the air. In the experiments here reported, the connection between root tubercles and assimilation of nitrogen which has been brought out by Hellriegel is confirmed.

THE COMPOSITION OF ONTARIO OATS. By C. C. JAMES, Professor of Chemistry, Ontario Agricultural College, Guelph, Ont.

ANYTHING that can be added to our present knowledge of the oat plant should prove interesting and serviceable, as there are few agricultural plants more important. It is easily produced, growing upon poor soils, flourishing upon rich soils; it can be made to yield in great abundance, both in grain and in valuable straw; it is an almost universal food for man and beast.

The following table contains the analysis of ten samples of oats produced in Ontario and used during the present year on the Ontario Experimental Farm, Guelph.

VARIETY.	WATER.	CRUDE PROTEIN.	FAT.	SOLUBLE CARBO-HYDRATES.	CRUDE FIBRE.	ASH.
1. Egyptian White.	12.95	9 28	4.83	55.49	14.15	3.30
2. White Australian.	13.60	10.94	4.01	56.75	11.55	3.15
3. Rennie's Prize White.	13.61	9.75	4.13	57.47	12.23	2.81
4. Acclimatized Black Tartarian.	12.40	10.45	5.37	57.50	11.22	3.06
5. Bavarian.	13.30	11.19	5.95	55.57	10.30	3.69
6. Black Champion.	12.75	10.88	4.35	59.61	9.59	2.82
7. Improved Scotch Potato.	13.54	9.19	7.49	57.71	9.11	2.96
8. Cluster or Triumph.	11.53	11.81	6.41	51.97	15.41	2.87
9. Welcome.	12.99	8.53	4.25	61.89	9.23	3.12
10. Early Calder.	12.93	6.19	5.64	55.74	16.33	3.17
Average.	12.96	9.82	5.24	56.97	11.91	3.10

The physical properties of the same samples are partially represented in the following table:

VARIETY.	COLOR.	WEIGHT PER BUSHEL, LB.	WEIGHT OF 100 KERNELS, GRAMS.	NO. OF KERNELS PER BUSHEL.	
1. Egyptian White.	Yellow	39.94	2.829	640,391	moderately long and plump.
2. White Australian.	Dark yellow	38.24	2.894	599,365	
3. Rennie's Prize White.	Yellow	39.61	3.716	483,503	plump, medium length.
4. Acclimated Bl'k Tartarian.	Black	36.80	2.583	646,351	long, thin.
5. Bavarian.	Dark yellow	35.83	3.023	537,625	long, moderately plump.
6. Black Champion.	Dark brown	33.15	2.380	631,790	
7. Improved Scotch Potato.	Yellow	40.43	3.103	591,004	short, plump.
8. Cluster or Triumph.	Light yellow	36.91	3.253	514,669	
9. Welcome.	Yellow	35.19	3.160	505,132	
10. Early Calder.	Yellow	37.78	2.154	795,586	
Average.		37.39	2.910	594,542	

The average of 166 United States samples as given by Clifford Richardson (Bulletin 9, 1886, Washington, Agricultural Department) shows the following: weight per bushel 37.2 lb.; weight of 100 kernels 2.507 grams.

For comparison with other analyses I shall add the following:—

	WATER.	CRUDE PROTEIN.	FAT.	SOLUBLE CARBO-HYDRATES.	CRUDE FIBRE.	ASH.
Richardson, 179 samples.	6.42	10.76	6.64	66.67	6.33	3.18
Kœnig, 153 samples.	12.37	10.41	5.23	57.78	11.19	3.02
Brewer, 20 samples.	10.56	11.41	4.97	61.10	9.01	2.95
Jenkins, 25 samples.	10.94	11.38	4.81	60.05	9.85	2.97
Average of 10 above.	12.96	9.82	5.24	56.97	11.91	3.10

From which it will be seen that the best Ontario oats are of about the same composition as the German samples analyzed by Koenig.

SOME PECULIARITIES OF BUTTER. By Prof. H. W. WILEY, Washington, D. C.

[ABSTRACT.]

THE paper showed some peculiarities in genuine butter which would lead to its condemnation as spurious when judged by the ordinary standards.

These peculiarities are characteristic of butters from certain animals or certain kinds of food. They refer particularly to variations in the content of volatile acids, to changes in melting point, and to the occurrence of certain constituents of the food in the butter.

COMPOSITION OF THE SEED OF CALACANTHUS GLAUCUS. (Illustrated.) By Prof. H. W. WILEY, Washington, D. C.

[ABSTRACT.]

THE paper contained the data obtained in the analyses of the pods, hulls and clean seeds of the Calacanthus.

It also contained a description of a new alkaloid, Calacanthine, first discovered by Dr. Eccles, but not studied by him. The peculiar characteristics of this alkaloid and its chemical reactions were shown.

DYNAMICAL THEORY OF ALBUMINOID AMMONIA.[1] By Prof. ROBERT B. WARDER, Washington, D. C.

[ABSTRACT.]

I. Free ammonia is distilled in accordance with the equation

$$\log \frac{y}{y_o} = k \log \frac{x}{x_o}$$

where x = volume of fluid in retort,
y = weight of ammonia in retort,
k = coëfficient of volatility,
and zero subscript denotes initial conditions.

II. This formula is compared with determinations by Smart, published by Mallet in the National Board of Health Report for 1882.

III. The law of mass action, under certain (ideal) conditions, leads to the equation,

$$-\log \frac{z_r - (y + z)}{z_\infty} = A \frac{x_o - x}{x}$$

Where z = weight of ammonia in distillate,
z_∞ = final weight of ammonia in distillate, and
$y + z$ = total weight of ammonia formed.

IV. Distillation, at the same time, must conform to the equation

$$y = -\frac{x}{k} \cdot \frac{dz}{dx}.$$

Curves are shown, representing:

A, distillation of free ammonia.
a, *a*, *a*, successive fractions of free ammonia.
B, formation of albuminoid ammonia, $A = 1$.
C, " " " " $A = 0.1$.
D, distillation of albuminoid ammonia; from curve *B*.
d, *d*, *d*, successive fractions of albuminoid ammonia.
E, albuminoid ammonia in the retort.

V. An exterpolation formula, intended to find a correction for the residue in the retort, gives unsatisfactory results, for reasons explained.

VI. A comparison of theory with the progress noted by Smart, in the case of certain pure chemicals, shows that these are soon partly converted into intermediate products of relatively great stability; hence the difficulty in completing the reaction.

VII. The method of determination devised by Wanklyn is capable of numerous modifications, a few of which have been made by other chemists. The original directions are insufficient to give consistent results, and more definite conditions should be agreed upon.

[1] This paper is printed in full in Amer. Chem. Jour., 11, 365-378 (Sept., 1889).

Action of light on silver chloride. By Romyn Hitchcock, Washington, D. C.

[ABSTRACT.]

As the result of experiments with thin films of silver chloride exposed to light, it was found that there was invariably a loss in weight.

An apparatus was arranged in which thin plates of glass, such as are used for covers of microscopical mounts, covered with translucent films of silver chloride, could be exposed to sunlight in a current of hydrogen gas, and the chlorine set free absorbed in a solution of silver nitrate.

The results obtained were far more uniform than any hitherto reported, no doubt owing to the fact that the chloride was obtained in a condition that permitted the light to act uniformly throughout the film. All experiments made with the chloride in a massive form, such as results from the ordinary method of precipitation and subsequent agitation, either in washing or in passing a current of air through the suspended precipitate, are doubtless vitiated by the protective action of the surface-molecules of the precipitated particles. It was found that even with the thin films used in these experiments, one film would almost perfectly protect another film during a whole day with bright sunlight shining directly upon the plate.

This is the first time that the chlorine set free from silver chloride has been accurately determined by loss in weight and also collected and weighed as silver chloride.

The object of these experiments has been to determine:

1. Whether there is a loss in weight proportioned to the amount of chlorine set free.

2. Whether an oxychloride is formed by the action of light, this being a ready explanation of an obvious loss of chlorine without change in weight. Most experimenters have agreed that there is no loss in weight, but a strong odor of chlorine is noticeable. If an oxychloride is formed, the chlorine collected in the apparatus should exceed in weight the loss sustained by the silver chloride.

The conclusion arrived at is that the loss in weight of 0.100 gramme of silver chloride in sunlight amounts to about 0.005–0.006 gramme, and that the weight of chlorine set free, as determined with the apparatus, is very nearly the same and will probably be shown by subsequent experiments to be exactly the same. Hence, the action of light is to set chlorine free and no oxychloride is formed.

Silver chloride, acted upon by light in these experiments, yields up silver to dilute nitric acid in a relatively large quantity, but the proportion has not been quantitatively determined.

The investigations are not complete.

Spectrum photography. By Romyn Hitchcock, Washington, D. C.

[ABSTRACT.]

A general review of the spectrographic work recently done by Mr. Victor Schumann of Leipzig, where the writer spent several days last winter,

and an exhibition of a number of photographs on glass, some of them taken with a train of nine quartz prisms. Mr. Schumann has been engaged for many years in studying the ultra-violet lines of metallic spectra, and he has recently constructed a spectograph which will photograph the entire spectrum from λ 760 to λ 185 on a single plane, covering a length of 80 cm., all the lines being sharply defined.

The extreme ultra-violet rays, which have been declared to be unable to pass through a short column of air, owing to the absorbing action of the air upon them, have recently been photographed through a column of air two metres long. This refers to the extreme lines of zinc and aluminium.

The action of coloring matters upon the sensitiveness of plates has long been a subject of investigation by Mr. Schumann, to whom we are indebted for our best knowledge of the action of cyanine, which is shown on some of the plates exhibited.

The definition of lines even with nine prisms is extremely good, but the lines are very fine and delicate, not to be compared with those of Professor Rowland's large diffraction plates. On the other hand, the train of prisms gives more light than a grating of the same dispersion.

A METHOD OF MOUNTING PHOTOGRAPHIC PRINTS ON PAPER. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

A METHOD of mounting photographic prints on thin paper without cockling has long been desired, in order that prints may be bound in a convenient form for reference. Cards are too bulky and heavy for large numbers of prints. After numerous experiments, the author succeeded in preparing a cement composed of shellac and mastic, which serves the purpose perfectly well. Prints may be mounted on paper, retaining their gloss and forming light and tasteful books.

SOME NOTES ON THE ESTIMATION OF NITROGEN BY THE KJELDAHL METHOD. By M. A. SCOVELL, Director Kentucky Agricultural Experiment Station, Lexington, Ky.

[ABSTRACT.]

1. Results obtained on C. P. Nitrates by the "Official Method."
2. By variations.

INTERNATIONAL STANDARDS FOR THE ANALYSIS OF IRON AND STEEL. By Prof. JOHN W. LANGLEY, Pittsburg, Pa.

[ABSTRACT.]

A SYSTEM of International standards has been arranged for with England, France, Germany, Sweden, and for the United States.

A description of the system was given and the Section asked to name one chemist to act with six others to conduct the analyses on behalf of the American Committee on the International Standards, and to cooperate with European Analysts.

JADEITE AND NEPHRITE. By Dr. L. P. KINNICUTT, Worcester, Mass.

[This paper will be printed in full in the Proceedings of the American Antiquarian Society. Vol. VI, Part 1, 1889.]

THE RELATION BETWEEN EVAPORATIVE TESTS UNDER BOILERS AND PROXIMATE CHEMICAL ANALYSES OF COALS AS DETERMINED FROM NINETEEN SOUTHERN COALS. By Prof. OLIN H. LANDRETH, Vanderbilt Univ., Nashville, Tenn.

ON THE USE OF FLUORIAL COMPOUNDS IN SOFTENING HARD WATERS. By Dr. CHARLES A. DOREMUS, 92 Lexington Ave., New York, N. Y.

ON THE DETECTION OF MORPHIA IN URINE. By Dr. CHARLES A. DOREMUS, 92 Lexington Ave., New York, N. Y.

Report of the Committee on Spelling and Pronunciation of Chemical Terms.

Your committee sent out, to American chemists, in May, 1889, a provisional list of words based upon the list compiled by Prof. J. H. Appleton, of Brown University, with a request for criticism. To this twenty-six replies were received, which were digested by the committee, and a report based upon these replies and upon careful study of the subject was presented to the Chemical Section at the Toronto meeting. It was voted by the Section that this report be printed and copies sent as far as practicable to all American chemists for criticism. The list presented in the original report has been revised and contains the recommendations as voted by the Chemical Section. Words thus voted on are designated by an asterisk. Spelling and pronunciation marked by a dagger were accepted by the Section without criticism.

It is extremely desirable that the next report of the committee should be thoroughly representative and therefore the coöperation of every American chemist is earnestly sought. It is hoped that every chemist will examine the list and plainly note *all* alterations in spelling and pronunciation which may seem to him desirable, and at the same time as far as it will not entail too much labor, give reasons for changes?

Replies are requested before March 1, 1890.

Thomas H. Norton, *Chairman*,
University of Cincinnati,

Edward Hart,
Lafayette College,

H. Carrington Bolton,
New York,

Jas. Lewis Howe,
Polytechnic Society, Louisville, Ky.,

Committee.

Please send replies to

Dr. Jas. Lewis Howe,
Polytechnic Society,
Louisville, Ky.

GENERAL PRINCIPLES OF PRONUNCIATION.

1. The pronunciation should be as much in accord with the analogy of the English language as possible, yet continental pronunciation should be approached, inasmuch as it is used by a large proportion of the world's chemists, and by a continually increasing number of American chemists.
2. Present usage should be retained as far as possible.
3. Derivatives should keep as far as possible the accent and pronunciation of the root word, in order to make the original sense as clear as possible. This is subordinate to Rule 1.
4. Distinctly chemical compound words should retain the accent and pronunciation of each portion.
5. Similarly sounding endings for dissimilar compounds should be avoided, hence -ĭn, -ĭd, -īte, -āte.
6. Utility often determines usage even when contrary to analogy.

PREFIXES.

General Rule. All prefixes in strictly chemical words should be considered as parts of compound words, and hence should retain their own pronunciation, unchanged.

mō'no-	nī'tro- or nĭ'tro- (Hart: nī'tro-)	anhȳ'dro-
dī-	nītrō'so- or nĭtrō'so-	arsĕ'nio-
bī-	ă'zo-	xă'ntho-
trī-	dīă'zo-	ī'so- (Howe: ĭ'so-)
tĕ'tra-, etc.	ă'zo-ă'mido	mĕ'thyl-
ă'cēto-	hȳ'dro-	ĕ'thyl-
*ă'mido- (Bolton: amĭ'do-)		prō'pyl-, etc.

NON-METALS, ETC.

hy'drogen	glȳ'cogen	sŭ'lphur
ŏ'xygen	ămĭ'dogen	phŏ'sphorus
nī'trogen	* chlō'rĭn	ca'rbon
hă'logen	* brō'mĭn	bō'ron
cȳă'nogen	* ī'odĭn	sĭ'licon
dī''cya'nogen	* flū'orĭn	†arsĕ'nicum
pă'racya'nogen		

Fāte, făt, făr, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mŏve, tūbe, tŭb, rūle, mȳ, ȳ = ī.

' Primary accent; '' secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

METALS.

Usage has determined the pronunciation except in a few instances.

ă′ntimony	ma′nganese (ez as in breeze.)	ku′pferni′ckel (koop)
bi′smuth (biz-)	me′rcury	si′lver
cō′balt	ni′ckel	tŭ′ngsten
co′pper		zinc
i′ron		

Words in *-ium* have antepenultimate accent, and the vowel of this syllable is short if *i* or *y*, or if before two consonants, but long otherwise.

*alū′minum (Bolton & Howe: alumi′nium)	irĭ′dium	strŏ′ntium (shium)
ammō′nium	lĭ′thium	tellū′rium
diĕ″thylammō′nium	magnē′sium (zhium)	te′rbium
bā′rium (Bolton: bă′rium)	niō′bium	thă′llium
berȳ′llium	ŏ′smium	thō′rium
cad′mium	pallā ′dium	†tītā′nium
caē′sium	phosphō′nium	ūrā′nium
ca′lcium	diĕ″thylphosphō′nium	vănā′dium
cē′rium	potă′ssium	ytte′rbium
chrō′mium	rhō′dium	ȳ′ttrium
†dīdȳ′mium	ruthē′nium	zircō′nium
e′rbium	samā′rium	lă′nthanum
ĭ′ndium	sca′ndium	†mŏlȳ′bdenum
	sĕlē′nium	plă′tinum
	sō′dium	tă′ntalum

TERMINATIONS IN -IC.

Accent penultimate.

Penultimate vowel in polysyllabic words short, except (1) *u* when not before two consonants; and (2) when penultimate syllable ends in a vowel; in dissyllables long, except before two consonants.

alūmi′nic	†ni′ckelic (ni′ck'lic)	bora′cic
ammŏ′nic	plati′nic	bō′ric
argĕ′ntic	plŭ′mbic	brō′mic
bā′ric	strŏ′ntic	carbŏ′nic
bismū′thic	tītă′nic	dīthiō′nic
coba′ltic (a as in ball)	ūră′nic	fĕ″rrocȳă′nic
mangă′nic		hydriō′dic
mercū′ric	arsĕ′nic	hy″drochlō′ric

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marîne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, ȳ = ī.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the sion of the word into syllables.

ĭŏ′dic	benzō′ic	phthă′lic (tă′lic)
mĕ″tantimŏ′nic	butȳ′ric	pĭ′cric
mĕ″taphosphŏ′ric	cacodȳ′lic	prŭ′ssic
mĕ″tastă′nnic	camphŏ′ric	†racĕ′mic or racē′mic
mŏlȳ′bdic	carbă′mic	rosĕ′llic
phosphŏ′ric	carbŏ′lic	sacchă′ric
py″rophosphŏ′ric	carbŏ′nic	salicy′lic
sĕlĕ′nic	†chlō″racĕtic or chlō″-racĕ′tic	sebă′cic
silĭ′cic		sūbĕ′ric
sŭ″lphocȳă′nic	chrȳsophă′nic	tärtă′ric
tellū′ric	cinnă′mic	†valĕ′ric or valē′ric
abiĕ′tic	cĭ′tric	succĭ′nic
†acē′tic or acĕ′tic	cyanū′ric	
abietĭ′nic	dĭălū′ric	alĕ′mbic
abs′inthic	fūmă′ric	allotrŏ′pic
ăcĕ′ric	glycŏ′lic	aromă′tic
ăcētŏ′nic	hippū′ric	atŏ′mic
ăcētȳ′lic	hȳpogaē′ic	bā′sic
aconĭ′tic	ĭ″sobutȳ′ric	elĕ″ctrolȳ′tic
acrȳ′lic	mā′lic	ĭsomĕ′ric
adĭ′pic	malŏ′nic	mō″nobā′sic
alcohŏ′lic	mellĭ′tic	mō″nohȳ′dric
aliză′ric	methy′lic	polymĕ′ric
allȳ′lic	mū′cic	tĕtratŏ′mic
amygdă′lic	myrŏ′nic	trĭbā′sic
amȳ′lic	olē′ic	

TERMINATIONS IN -OUS.

Words in *-ous*, following the general rule of the language, take antepenultimate accent, except when two consonants follow the penultimate vowel, in which case the accent is thrown forward.

(A clear distinction is thus made in accent as well as in termination between words in *-ic* and *-ous*.)

†acē′tous (exception through usage)	sĕlē′nious	plă′tinous
arsē′nious	sŭ′lphūrous	tĭ′tanous
chlō′rous	tĕ′llūrous	alliā′ceous
hy″drosŭ′lphūrous	bĭ′smūthous	alumenĭ′ferous
hy″pochlō′rous	chrō′mous	amȳlā′ceous
hy″ponĭ′trous	cō′baltous	aurĭ′ferous
hy″pophŏ′sphŏrous	mă′nganous	gă′seous (gazeous)
hy″posŭ′lphūrous	mĕ′rcūrous	gela′tinous
phŏ′sphŏrous	nĭ′ckelous	pyrolĭ′gneous

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, ȳ = ĭ.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

TERMINATIONS IN -ATE.

Antepenultimate accent (occasionally thrown back).

ă′bĭĕtāte	alĭ′zarāte	cȳ′ănāte
ă′cerāte	ammō′nĭāte	fŭ′lmināte
ă′cētāte	amȳ′gdalāte	glȳ′cŏllāte
ă′cetonāte	ă′mylāte	vă′nadāte
ă′dipāte	antĭmō′nĭāte	†tĭ′trāte
ă′lcoholāte	ă′rsenāte	

TERMINATIONS IN -ITE.

Accent analogous to *-ate* terminations.

ă′cetīte	ă′rsenīte	mă′nnīte
ă′ntimonīte	hy″pophŏ′sphīte	

TERMINATIONS IN -IDE AND -ID.

* Drop final *e* in every case, and pronounce *-ĭd* (see note I). Antepenultimate accent.

ă″cētă′nilĭd	cȳă′melĭd	ă′lkală′mĭd
hȳ′drĭd	glū′cosĭd	bĕ′nzylă′mĭd
anhȳ′drĭd	hy″drosŭlphĭd	că′rbă″mĭd
ă′nilĭd	ŏ′xĭd	cȳă′nă″mĭd
brō′mĭd	hȳdrŏ′xĭd	dĭ′ă′cētă′mĭd
chlō′rĭd	murĕ′xĭd	dīcyă′nă″mĭd
flū′orĭd	ŏ″xychlō′rĭd	lă′ctă″mĭd
ī′odĭd	ă′mĭd	ŏ′xă″mĭd
cȳ′ănĭd	ă′cētă′mĭd	

TERMINATIONS IN -ANE.

Hydrocarbons belonging to the *-ane*, *-ene*, and *-ine* groups of Hofmann take long vowel.

mĕ′thāne	hĕ′ptāne	ī″sobū′tāne
ĕ′thāne	ŏ′ctāne	ī″sopĕ′ntāne
hĕ′xāne		

TERMINATIONS IN -ENE.

Antepenultimate accent. Some dissyllables, as benzene, have no distinct accent.

ă″cēnă′phthēne	ăcĕ′tylēne	ă′mylēne
ă′cētnă′phthylēne	ă′llylēne	†ă′nthracēne

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rule, mȳ, ȳ = ī.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

ă'sphăltēne	dībrōmbĕnzēne	oēnanthȳ'lidēne
ă''zobĕ'nzēne	ĕ'thidēne	pĕ'ntylēne
bĕnzēne	ĕ'thylēne	phenă'nthrēne
bĕ'nzylēne	hĕ'ptylēne	terabĕ'nthēne
bū'tylēne	ī''sobū'tylēne	tŏ'lūēne
caprȳ'lidēne	ī''sohĕ'ptylēne	valĕ'rylēne
cētēne	mesī'tylēne	xȳ'lēne
crotŏ'nylēne	mĕ''taxy'lēne	
decĕ'nylēne	mē'thylēne	glū'tĕn
diă'mylēne	nă'phthalēne	*albū'men

TERMINATIONS IN -INE.

Doubly unsaturated compounds in *-ine* take the normal pronunciation *-īne*.

ĕ'thine	prō'pīne

TERMINATIONS IN -IN.

*All chemical compounds now ending in *-in* and *-ine* (except doubly unsaturated compounds, considered above) should end in *-in*, and this syllable should be pronounced *-ĭn* (see note 2).

The accent is antepenultimate, except when the penultimate vowel is followed by two consonants, in which case the accent is penultimate.

chlō'rĭn	ă'tropĭn	quī'nidĭn
brō'mĭn	bĕ'nzĭn	quī'nĭn
ī'ŏdĭn	brū'cĭn	rōsă'nilĭn
flū'ŏrĭn	chō'lĭn	stry'chnĭn
ă'mĭn	chrȳ'soidĭn(oi as in soil)	tolū'idĭn
mĕ'thylă'mĭn	cinchŏ'ncĭn	vă'sēlĭn
ĕ'thylă'mĭn	cī'nchōnĭn	ă'bīĕtĭn
ă''cēdiă'mĭn	cō'nĭn	absī'nthĭn
ă'cetonă'mĭn	crēă'tinĭn	ă'cētĭn
phŏ'sphĭn	crē'atĭn	alī'zarĭn
ä'rsĭn	cū'rarĭn	alloxă'ntĭn
ă'conĭn	guä'nidĭn (gwä)	ă'llylĭn
acŏ'nitĭn	guä'nĭn (gwä)	amȳ'gdalĭn
ă'mmelĭn	hȳ'drazĭn	ă'mylĭn
ă''nthrapu'rpurĭn	hyoscȳ'amĭn	au'rĭn
ă'sbolĭn	mo'rphĭn	conī'ferĭn
ă'nilĭn	ō'lĕfĭn	cū'marĭn
aspă'ragĭn	quī'nicĭn	dĕ'xtrĭn

Fāte, făt, får, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, ȳ = ī.

' Primary accent; '' secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

dichlōrhȳ'drin
diĕ'thylin
distē'arin
emŭ'lsin
fi'brin
flŭorĕ'scin
gĕ'latin
glŏ'bŭlin
glī'adin
glū'tin
gly'cerin (gly'cerōl preferred)
†hĕ'moglō'bin
†hĕ'matin
†ī'ndigotin
ī'nulin
ī'satin
leū'cin
mō''nostē'arin

mȳ'osin
nä'rcotin
neū'rin
nī'cotin
pă'lmitin
păpă'verin
pĕ'psin
pīpĕ'ridin
pu'rpurin
reso'rcin
să'licin
sä'rcin
stē'arin
sy'ntōnin
tă'nnin
*vă'nillin

(*In following nine words, penultimate accent obscure.*)

thē'bain
†cō'cain
acrō'lein
că'ffein
cō'dein
că'sein
flŭorĕ'scein
nä'rcein
cōnīin
*thē'in (tēin) (Hart: word should be dropped).

allă'ntōin
†bĕnzōin

ă'lkaline
cry'stallin or cry'stalline.

TERMINATIONS IN -ONE AND -ON.

*albū'minōne
ă''nthraquinōne
quinōne
kētōne

ă'cētōne

bō'rōn
că'rbōn

hȳ''drŏcă'rbōn
collō'diōn
sī'licōn

TERMINATIONS IN -AL, -IL, -OL, -YL, -YDE, ETC.

ă'cetăl
bĕ'nzăl

chlō'răl
nī'tril

ă'cētonī'tril

-ol, final *e* dropped; *-ōl*, with two exceptions from usage.

ă'lcohōl
ă'nĕthōl
ä'rgōl
be'nzōl (undesirable, should be dropped.)

crĕ'sōl
glȳ'cerōl
†glȳ'cōl
ī'ndōl

†nă'phthōl
*phĕ'nōl
*thȳ'mōl (ti)

-yl, antepenultimate accent.

ăcĕ'tonȳl
†ăcētȳl
ăllȳl

ă'mȳl
bī'smūthȳl
bō''rĕ'thȳl

bū'tȳl
că'codȳl
că'rbonȳl

Fāte, făt, fär, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rüle, mȳ, ȳ = ī.

'Primary accent; '' secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

†cărbŏ′xy̆l	dīphĕ′ny̆l	lă′cty̆l
cē′roty̆l	dīprō′py̆l	mĕ′thy̆l
cē′ty̆l	fo′rmy̆l	†nītrŏ′xy̆l
chrō′my̆l	hĕ′pty̆l	nī′try̆l
dīă′lly̆l	†hydrŏ′xy̆l	ŏ′cty̆l
dīă′my̆l	ī″sobū′ty̆l	†phĕ′ny̆l
dīmĕ′thy̆l	ī″soprō′py̆l	prō′pēny̆l

-yde, antepenultimate accent.

†ă′ldehȳde	bĕ″nză′ldehȳde	pă″ră′ldehȳde
ă′cētă′ldehȳde.	mĕ″tă′ldehȳde	

-METER.

† Words ending in the termination *-meter* take the normal antepenultimate accent (from usage); except that the words of this class used in the metric system are considered as compound words, and each portion retains its own accent.

ăcētĭ′meter	mīcrŏ′meter(instrument)	dĕ′cimē″ter
ăcētŏ′meter	ureŏ′meter	hĕ′ctomē″ter
ăcĭdĭ′meter	urinŏ′meter	kĭ′lomē″ter
alcholŏ′meter		my̆′riamē″ter
alkalĭ′meter	mĭ′llimē″ter	mĭ′cromē″ter (measure)
bārŏ′meter	cĕ′ntimē″ter	
eudiŏ′meter	dĕ′kamē″ter	

MISCELLANEOUS.

brō′moform	ăcētĭ′metry	bī′vā″lent
chlō′roform	ăcĭdĭ′metry	trī′vā″lent.
iō′doform	alcoholŏ′metry	† qua′drivā″lent
ă′mylōse	alkalĭ′metry [in boil.)	quĭ′ntivā″lent
cĕ′llulōse	† stoichiŏ′metry (oi as	atomi′city
dĕ′xtrōse	alcoholomĕ′tric	basĭ′city
glū′cōse	baromĕ′tric	mō′nad
lă′ctōse.	acētificā′tion	tĕ′trad
†lĕ′vūlōse	cupellā′tion	†ă′llotrŏpy
ma′ltōse (a as in ball)	distillā′tion	† ă′llotrŏpism
sū′crōse	ebullĭ′tion	† ī′somerism
sy′năptāse	fermentā′tion	† pŏ′lymerism
ă′lkaloid (oi as in boil.)	lixiviā′tion	ană′lysis
ă′myloid (oi as in boil.)	† titrā′tion	atmŏ′lysis
cŏ′lloid (oi as in boil.)	vā′lence	dīă′lysis
cr′ystalliod (oi as in boil.)	qua′ntivā″lence	electrŏ′lysis
* albū′minoid (oi as in boil.)	mō′novā″lent	acĕ′tify

Fāte, făt, fār, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rūle, mȳ, y̆ = ĭ.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllables.

acĭ′dĭfy	† grăm (so derivatives)	† băry̆′ta
ā′erate	† lĭter	bō′rax
āĕ′riform	† tĭter (to be avoided)	că′ramel
† alloy′ (noun)	†tĭ′trāte	lĭ′tharge
† alloy′ (verb)	† tĭtrā′tion	† ōlē′fiant
amă′lgam	ammō′nia	salt pe′ter
amă″lgamā′tor	ammō′niac	ve′rdigris
* apparā′tus	ammōnī′ăcăl	ăcĭ′cular
*apparā′tus (plural)	* ă′ntimonetted	ă′lchĕmist
† a′ssay (noun)	* ă′rsenetted	ă′node
† assay′ (verb)	că′rburetted	ăqua fo′rtis
† assay′er	te′llūretted	ăqua rē′gia (re-gi-a)
* cŏ′ncentrated	sŭ′lphūretted	cĕ′ntigrade
dĕ′flagrating	phŏ′sphoretted	crystallŏ′graphy
dĭlū′te	ă′dipocere	fū′marole
* mō′lecule	ă′lkali	găngue
* mōlĕ′cular	ă′lkanet	me′tallu″rgy
fe′rment (noun)	†allŏ′xan	* nō′mĕnclā″ture
ferme′nt (verb)	ă′ntichlor	* ra′dical
na′scent	† asbe′stos	speĭss (spīce)
† mē′ter	ă′sphălt	tū′bulature

Fāte, făt, făr, mēte, mĕt, pīne, pĭn, marīne, nōte, nŏt, mōve, tūbe, tŭb, rūle, my̆, y̆ = ĭ.

′ Primary accent; ″ secondary accent. N. B. The accent follows the vowel of the syllable upon which the stress falls, but does not indicate the division of the word into syllaples.

NOTE 1. *-ĭd*. This pronunciation distinguishes clearly between *-ĭd* and *-īte*. In German it is difficult and often impossible to distinguish between *-id* and *-it*, and in English a confusion often arises between chlorite and chloride, sulphite and sulphide, etc.

See also the following note.

NOTE 2. *-ĭn*. The final *e* in these words should be dropped as of no important significance.

I. The suggestion of Watts and others to indicate basic substances by *-ine* and all others (or neutral substances) by *-in* seems unwise. It makes a difference in spelling, with little or no corresponding difference in pronunciation on the part of most chemists,— a useless and undesirable complication. It demands a very extensive knowledge of the constitution of a great number of compounds with these terminations. It has been partially adopted by many chemists but not consistently by most, and by many it has never been recognized.

II. All continental languages use the pronunciation *-ĭn* and this is the case with not a few words in English as benzīne, marīne, while the American public have instinctively taken up this pronunciation in "Pearlīne, Soapīne," etc. In general however it seems too foreign to English usage to be adopted by a majority of American chemists.

-īne is awkward and would be very foreign to English usage in many words, as chlorīne, morphīne, nicotīne, brucine, etc., etc.

The pronunciation *-ĭn* is already common in many of these words, as the halogens, anilĭn, hematĭn, pepsĭn, tannĭn, etc., and at the same time presents a near approach to the continental *ĭn*, into which it may easily be strengthened if preferred.

The above note applies equally to the termination *-ĭd*.

SECTION D.

MECHANICAL SCIENCE

AND

ENGINEERING.

OFFICERS OF SECTION D.

Vice President.

JAMES E. DENTON of Hoboken, N. J., in the absence of ARTHUR BEARDSLEY of Swarthmore, Pa.

Secretary.

W. R. WARNER of Cleveland, Ohio, in place of J. E. DENTON elected Vice President.

Member of Council.

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Members of Sub-committee on Nominations.

J. GAILBRAITH of Toronto, Ont., A. E. DOLBEAR of College Hill, Mass., THOMAS GRAY of Terre Haute, Ind.

PAPERS READ.

ON THE RELATIVE PERFORMANCE OF MODERN AIR COMPRESSORS. By Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

RESULTS of measurements of the power expended in compressing air to high pressures are given by means of data from indicator cards collected from most of the makes of air-compressing machines used for tunnelling operations in Europe and America. It is shown that all attempts to maintain the temperature of air uniform, during compression by the injection of water, either in the form of spray or *en masse*, fail to cause the compression curve to become coincident with an isothermal or Mariotte line. The curve of compression actually realized by the use of water in the most effective manner coincides with an hyperbola whose form is represented by the equation $p\ v\ 1.22 = \text{constant}$, p being the absolute pressure and v the volume of the air compressed. This is equivalent to the statement that if the saving in power expended to compress air along an isothermal as compared to compressing it along an adiabatic be represented by unity, the saving actually realizable by any cooling with water is only about one-half. It appears that even when the temperature of the compressed air is maintained at less than 100° Fahr. at exit from the compressing cylinder, the power saved is no greater than the above amount.

The general conclusion drawn is that the cooling of the air is accomplished mainly during the ejection of the air from the compressor *after the compression is completed*.

It is also shown that water jacketed compressors realize the economy of water injection compressors so nearly, that in view of the injurious effects of water in the cylinders, the jacket system is the most economical commercially.

ON THE CYLINDER CONDENSATION OF MULTIPLE EXPANSION ENGINES. By Prof. J. E. DENTON, Stevens Institute, Hoboken, N. J.

[ABSTRACT.]

ATTENTION is called to the fact that the most recent reliable experiments with engines indicate that the steam unaccounted for by the indicator is approximately proportional to the product of the time of admission and the

range of temperature due expansion in the cylinder taking steam directly from the boiler and the surface to which steam is exposed at the instant of cut-off in this cylinder. It follows that the percentage of steam unaccounted for by indicator in the case of multiple expansion engines is not greater and may be less than for single cylinder engines having equal ratios of expansion and equal power.

Resistance of air to inclined planes in motion. By O. Chanute, 5 Ritchie Place, Chicago, Ill.

[Abstract.]

Pénaud stated in 1876, that the laws of fluid pressures as laid down by Newton did not agree with experiments with inclined planes, and T. W. Mather, in an article in the Popular Science Monthly in 1885, stated that mathematicians were yet unable to accurately calculate the sustaining reactions and resistances which birds meet with in their flights. There are also serious anomalies in the calculated wind effects on bridges and roofs as compared with actual disasters.

The author recently conceived a new theory on the subject, and being in Europe, he presented it briefly before the International Congress of Aeronautics at Paris, where it was received with such favor, that although it is still crude and undeveloped, he believes it is worth presenting to the American Association for the Advancement of Science for criticism and discussion.

The theory is based upon two generally accepted laws:

1. That fluid pressures are in direct proportion to the number of molecules affected by the motion. 2. That the pressure of a fluid jet in front of a plane is correctly given by Rankine's formula $F = \frac{d A \Delta^2}{g}$ in which the height of the pressing column is assumed to be double that producing the velocity.

The author suggests that there is no warrant for assuming that the geometrical figure enclosing the molecules is that of a column, but that it may be a prismoid, with flaring sides, with only the height due to the velocity, and still enclose double the number of molecules of a parallelopipedon of equal altitude.

He believes that when air is compressed, the molecules press not only upon the plane, but also sidewise upon those outside of the direct line of current, so that the cleavage of the air, so to speak, flares out at angle from the plane. He believes that a further action takes place behind the plane in consequence of the partial vacuum produced by the current rushing by.

The author believes that further experiments (which he indicates) are required to work out general formulæ, but he gives some approximate for-

mulæ, and five tables, showing how the results of experiment disagree with the old theory, and seem to agree closely with the new. He also states some of the consequences of the new theory, as to various phenomena of wind pressures.

He applies the formulæ to the measure of the sustaining reactions and resistance of the air to a soaring pigeon, and shows that at twenty-five miles per hour, an angle of 1° with the horizon is sufficient to produce a pressure which will sustain the weight of the bird, while the work done is at the rate of 10½ horse power per ton of weight, or about one-third that hitherto required for navigable balloons.

PRESERVING WOOD AGAINST DECAY. By O. CHANUTE, 5 Ritchie Place, Chicago, Illinois.

[ABSTRACT.]

THE growing scarcity of wood in this country is forcing upon our attention economical means of lengthening its resistance to decay.

The Europeans have been compelled by the same reason to experiment largely with various chemicals, and during the last forty years have achieved such success that a railway manager is now not considered a prudent manager, if he fails to avail of some of them.

At least four methods have proved a success; they are:

(1) Kyanizing, or preserving with corrosive sublimate.
(2) Cupperizing " " " sulphate of copper.
(3) Burnettizing " " " chloride of zinc.
(4) Creosoting " " " dead oil of coal tar.

The first two methods are gradually losing ground, but the last two are now largely employed. Of these creosoting is the most effective, but also the most costly, and in view of the yet smaller price of timber in this country, it would seem to the author that the best process for us to use at present is that of burnettizing, particularly for railway ties which are destroyed in part by the mechanical action of the foot of the rail cutting into them, in addition to the operation of decay.

In applying either of the above methods, great care is to be observed to have the work well done, the wood well prepared for absorbing the solutions, and the latter to be of good quality, neither too weak nor too strong. Until the working of the processes are thoroughly understood, it will be best to have them supervised by experts.

The selection of the kinds of wood to be treated is also quite important. Close grained timber such as white oak or chestnut should not at present be treated at all. It is better to use it unprepared, but the more porous woods, such as hemlock, bastard pine and beech will take the treatment well, and the life of wood will be at least doubled thereby.

Reference is made to the report of a special committee of the American Society of Civil Engineers in 1885, for further details and records of experiments.

NOTE ON THE PERFORMANCE OF A VIBRATING PISTON ENGINE. By Prof. M. E. COOLEY, Ann Arbor, Mich.

[ABSTRACT.]

THE following results were obtained from a test on an 8 to 10 H. P. Kimble engine, manufactured by the Kimble Engine Co., Kalamazoo, Mich. The piston is 4½ inches wide and 6 inches long and attached to a 2-inch shaft at the middle of its length; the ends of this shaft by means of arms, wrist-pins, and connecting rods, connect with the cranks on the main shaft. Steam is admitted through ports at the extremities of the arc of the circle of the top of the cylinder by means of a rocking valve operated by an excentric on the main shaft controlled by an automatic governor.

The engine when tested was new, never having had steam on it before, and was not run more than ten minutes before the friction test was begun. The friction under loads varying from 2.39 I H. P. to 13.37 I H. P. averaged 22.6 per cent, and was nearly constant.

With a boiler pressure of 81.4 lbs. and a cut-off at about ½ stroke at 375 revolutions per minute the consumption of dry steam per I H. P. per hour averaged 41.32 lbs. (calorimeter tests showed the steam to contain only 2 08 per cent. moisture). The back pressure was so high, owing to a faulty valve, that the horse power was measured down to the atmospheric line for purposes of comparison.

Average total horse power	12.237
" net " "	10.121
" lost " " (due to back pressure)	2.046

Steam per total horse power per hour = 34.41 lbs.

Considering the size of the engine, the fact that it was perfectly new, and also that the steam connections were not as direct as they should have been, the results as stated may be considered quite equal to those obtained from reciprocating engines under similar conditions.

NOTE ON THE FRICTION OF WATER IN PUMP PASSAGES. By Prof. M. E. COOLEY, Ann Arbor, Mich.

[ABSTRACT.]

A TEST for duty made on a compound duplex pumping engine developed the following results:

Dimensions of pumps. Diameter of H. P. cylinder, 14 inches; L. P. cylinder, 26 inches; water plunger, 14 inches; stroke, 18 inches; daily capacity, 2,000,000 gallons; diameter suction, 14 inches; diameter force main, 12 inches; length force main, about 4000 feet; height of discharge above centre of plungers, 198.5 feet.

Performance of pumps.—

Average steam pressure in boiler (by gauge),	76.2 lbs.
" vacuum in condenser,	21 92 ins.
" total pressure in force main,	99.35 lbs.
" suction in suction pipe,	11.28 ins.
" total head pumped against in feet of water,	244.6

All of the preceding results were secured by using sensitive gauges, standardized. The pressure in the force main was taken on a level with centre line of plungers, and the suction, from the head of the suction pipe and at the same level.

The following results were secured by using indicators having short 1-inch connections with the water cylinders.

Average mean effective pressure in the water cylinders,	114 lbs.
Equivalent head in feet of water,	265
Difference of head as measured outside and inside the cylinders,	20.4 ft.

$\frac{265 - 244.6}{244.6} = \frac{20.4}{244.6} = 0.0834$, or the duty as measured in the pump cylinders is 8.34 per cent. greater than that in the mains just outside the pumps.

The following partial heads go to make up the total head:

Height of discharge above centre of plungers,	198.5 feet.
" " suction to " " "	12 8 "
" due to friction in force main (computed)	22.4 "
" " " " of elbows, valves and other obstructions in force main, etc.,	10.9
Friction of valve and other passages in pump,	20.4
Total,	265.

Four six-inch rubber disc valves were used in each end of water cylinders, held down by coil springs. The suction was common to both cylinders, and the discharge pipes from the pumps abut directly against each other, the force main branching out from these pipes at a sharp right angle, the air chamber being placed on top at the common point of meeting.

The average piston speed under which the preceding results were obtained was about 97 feet per minute; at higher speeds the friction became much greater.

NOTES ON ANTI-FRICTION CONSTRUCTION FOR THE REVOLVING MECHANISM FOR OBSERVATORY DOMES. By W. R. WARNER, of Cleveland, Ohio.

[ABSTRACT.]

IN the construction of the observatory domes for the University of Virginia, Johns Hopkins University, Smith College and many others, the sliding friction has been entirely eliminated, and therefore no lubrication is required or provided for.

The line ring is jointed and flexible and the conical wheels have no flanges.

The wall plate forming the tracks is accurately turned to the proper cone so that when the conical wheels are in position their top surfaces are level, and therefore the track on the sole plate or base ring of dome is a plane instead of a cone. The dome is held in lateral position by guide wheels carried by armatures reaching from the base ring of the dome to the wall plate.

The axes of each conical wheel are held in a light cast iron yoke by ball bearings the same as are used in bicycles. These axes, however, sustain no weight except that of the light yoke and are only used to keep the axis a true radius of the circle of the dome. This is accomplished by two light lateral wheels attached to each yoke, these wheels having the same kind of ball bearings above mentioned. It will thus be seen that the conical wheels require no flanges, and that there is no place for sliding friction, all possible resistance being reduced to rolling friction.

The flexible line ring allows the walls of the observatory to change their shape without increasing the power required to revolve the dome, while the guide wheels attached to each yoke carrying the conical wheels keep the axis of each conical wheel a true radius of the part of the circle on which it is running.

The tests given these domes show that a direct pressure of 1½ lbs. per ton is sufficient to revolve them and after five years of use and exposure they turn just as easily as when first erected.

STEAM INJECTORS. By ERNEST B. PERRY, Industrial Works, Bay City, Mich.

ON A DIAGRAMMING APPARATUS FOR USE IN THE TESTING OF MATERIALS. By Dr. THOMAS GRAY, Terre Haute, Ind.

ACHIEVEMENTS OF THE SHARPNECK ROLLER-BEARING JOINAL BOX. By CHAS. D. WALCOTT, U. S. Geological Survey, Washington, D. C.

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ADDRESS

BY

PROFESSOR CHARLES A. WHITE,

VICE PRESIDENT, SECTION E.

THE NORTH AMERICAN MESOZOIC.

It has become customary upon such occasions as this for the speaker to select a theme from subjects which he is supposed to have specially studied; and I have therefore chosen for mine the Mesozoic division of the geological record as it is exhibited on this continent. This theme is so comprehensive that I propose only to select from it certain topics which pertain to the distinguishing characteristics of the principal subdivisions of the Mesozoic that have been recognized in different portions of North America; to their interdelimitation and to the delimitation of the division as a whole from the Carboniferous system beneath, and the Cenozoic above. I shall also make the discussion of these topics the opportunity of expressing certain views which I hold concerning them.

To bring these discussions within the time allotted me they must be confined to three general sections of the Mesozoic formations, one of which occurs within each of three regions of the continent, namely, the Atlantic Coast, the Pacific Coast, and the Interior regions. Proceeding upon this plan let us first consider the general section which is to be observed in the Atlantic Coast region.

The rocks which in this region are now generally regarded as of Triassic age are found occupying limited isolated districts from Prince Edward Island on the north to the state of South Carolina on the south. If they extend further to the south, or southwestward, they are covered from view by later formations. They are found to rest unconformably upon various formations from the Archæan to the

Carboniferous inclusive; except perhaps in Prince Edward Island, where they are reported as resting conformably, or nearly so, upon reputed Permian strata. Still, no intimate stratigraphical or paleontological connection between the Permian and the Trias has been shown to exist there; and the hiatus between them is doubtless as great as it is farther southward, where the unconformity is so conspicuous.

In this latter portion of the region it is evident that the great uplift which involved the paleozoic rocks, including the reputed Permian, took place long before the deposition of the earliest of those Triassic beds. These stratigraphical conditions indicate that the hiatus in the geological record between the latest of the Carboniferous, and the earliest of the Triassic deposits is equal to at least the earlier half of the Triassic, as that period is represented in Europe.

The only known paleontological evidence which appears to bear upon this subject agrees with the stratigraphical indications just mentioned. That is, the results of investigations by Professor Newberry upon the fishes and plants of the strata in question, and of Professor Fontaine upon the plants of the same, indicate that they represent the later Trias of Europe. But if Triassic fishes had not survived to the present day; and if we knew more concerning the developmental stages in the vegetable kingdom from the later Paleozoic to the later Mesozoic inclusive, a good degree of uncertainty which is naturally felt upon this point would dcubtless disappear.

Our knowledge of the land vertebrate fauna which existed at the time these deposits were formed is derived mainly from footprints; and it is therefore more than usually imperfect. The character of this evidence as indicating Triassic, rather than earlier Jurassic age, seems to be far from unquestionable.

Very few invertebrate fossils have been found in the Trias of the Atlantic Coast region; and the few that have been discovered are of little or no value as indicating the age of the strata containing them.

As to the relation of these deposits with the Carboniferous system, only stratigraphical evidence has thus far been obtained, and this shows only the bare fact that the former are of considerably later age than the latter. That is, no direct, or even approximately close, biological relationship between them has yet been discovered, the biological hiatus being apparently quite as great as the strati-

graphical one. It may be mentioned here also that we have no evidence that the Trias of the Atlantic Coast was ever continuous, or that it was exactly contemporaneous, with the reputed Trias of the Interior region, which will be presently referred to.

Intermediate between the Triassic beds and the undisputed Cretaceous deposits of the Atlantic Coast region there is a series of strata, evidently of littoral and estuary origin, but, at least, in part, of doubtful age, to which the name of Potomac formation has been applied. These deposits reach at most only a few hundred feet in thickness, and although frequently covered from sight by later formations, they seem to have been originally continuous from New Jersey to the state of Mississippi. They have no known representative west of the Mississippi river, unless it shall be shown that they are represented by some sandy beds at the base of the Texas Cretaceous section. These Potomac beds are usually found resting directly upon the Archæan, and at only a few points are they found to rest directly upon the Triassic rocks, when they are plainly unconformable. They seem to be constantly present beneath the marine Cretaceous strata just mentioned and no representative of another formation has yet been observed between them.

Invertebrate fossils are exceedingly rare in the Potomac forma tion, and the few that have been found give no direct indication of its geological age. Professor Whitfield, however, has suggested that the Raritan Clays, together with the Amboy Clays, which by some geologists are included in the Potomac formation, but which are probably of later date, are of Jurassic age because of the similarity of his new lamellibranchiate genus Ambonicardia, with certain European Jurassic shells.

Large collections of fossil plants have been obtained from the deposits here provisionally grouped together under the name of Potomac formation, at numerous and widely separated localities. These collections differ so greatly in character from one another that it seems necessary to infer that more than one flora is represented by them. Many years ago Dr. Tyson found some fossil plants in Maryland which he regarded as of Jurassic age, and which closely resemble certain forms that are found in the European Jura. Professor Ward, in reviewing the large flora which Professor Fontaine has published from the Potomac formation in Virginia, and having in mind also the Maryland plants just referred to, recognizes the Jurassic character of several of the species, according to the Euro-

pean standard, but he takes the rational ground that all obtainable evidence ought to be considered before reaching a final decision as to the true age of the deposits containing them.

Professor Newberry, who has made extensive studies of the plant remains of the Raritan and Amboy clays, finds among them none that give any indication of their Jurassic age. On the contrary, he finds that the flora of those clays as a whole indicates that they ought to be referred to an epoch not later than the Middle Cretaceous of Europe, nor probably earlier than the upper Neocomian.

Professor Marsh has published some dinosaurian remains from apparently the same horizon in the Potomac formation that furnished the plants to Dr. Tyson and Professor Fontaine, which he has referred to the Jurassic.

Paleontological testimony being thus conflicting in its character, one naturally infers that more than one epoch is represented by the deposits that now bear the common name of Potomac formation; but I shall presently call your attention to some cases of commingling of earlier and later molluscan types in one and the same formation which are quite as remarkable as this apparent commingling of diverse plant and vertebrate types in the Potomac formation.

The marine Upper Cretaceous deposits of the Atlantic Coast region which immediately overlie the Potomac formation are best developed in New Jersey; but there is good reason to believe that they were originally continuous with contemporaneous deposits through the whole length of the region from Long Island to the Gulf states and thence westward to, and far northward within, the Interior region. This opinion is based upon specific identity of marine fossils discovered in the different regions.

The Upper Cretaceous of this region is overlain by Eocene deposits, also marine, with little if any observable unconformity where they have been found in contact. I shall, however, presently mention facts which indicate that there is in the Atlantic and Gulf Coast region a considerable hiatus between the Cretaceous and Eocene.

Briefly, then, the Mesozoic of the Atlantic Coast region consists of a probable representation of the Upper Trias of Europe, a possible one of the Upper Jura, a probable slight one of the Middle Cretaceous, and a practically certain representation of a large part of the Upper Cretaceous, but with an hiatus between the latter and the Eocene.

Although the Cretaceous rocks are, or were originally, continuous between the Atlantic coast and interior regions by way of the Gulf states, the earlier Mesozoic rocks of those regions respectively are so widely separated from each other that, as we go westward, we do not find any that can be confidently referred to either the Trias or the Jura until we have passed the 100th or perhaps the 103d meridian.

As the latter meridian coincides with the western boundary of Texas, the foregoing statement implies that no Triassic rocks exist within at least the greater part of the fully thirty thousand square miles in that state and the Indian Territory, which some geologists have represented as being occupied only by rocks of that age. A personal examination of a large part of that region and of the fossils collected there, has satisfied me that the sum of all the known evidence is in favor of the Permian age of the strata in question and against their Triassic age. But these strata have an important paleontological relation with the Mesozoic, to which I wish to call your attention for a few moments.

Upwards of fifty species of vertebrates, embracing reptiles, batrachians and fishes, have been described from these rocks by Professor Cope, upon the evidence of which he referred them to the Permian of Europe, although, as he states, not one of the genera is common to both continents.

I have collected upward of thirty species of invertebrates from the same beds which furnished the vertebrates, representative examples of all the more important of which were obtained from one and the same stratum. Of these, fully one-half are common, characteristic Coal-measure species. A part of the cephalopod species, however, possess such decided Mesozoic characteristics that probably no special student of that class of fossil mollusca would hesitate to refer them to a formation not older than the Trias, if they had been submitted to him without any information as to their true stratigraphical position.

It is a significant fact that if three special selections were made from the fossils of all kinds that have been obtained from this formation in Texas, one could be made, by the usual method of chronological classification practised by paleontologists, to prove its Coal-measure age, another its Permian age, and still another its Triassic age. It is admitted that the sagacity of an experienced paleontologist will often enable him upon limited evidence to be-

come satisfied in his own mind as to the approximate age of a given formation; but it is only after all the obtainable paleontological and stratigraphical facts are carefully considered together that one is justified in expressing a definite opinion upon a subject of this kind. Such a summing up of all the evidence at present available seems to fully justify the reference of this Texan formation to the Permian of Europe.

My special object in presenting the foregoing facts is to call your attention to the important paleontological relation of the Texan Permian with the Mesozoic, which is shown by the presence of Ammonitic and Ceratitic cephalopods among Paleozoic types of mollusks. The discovery of such forms in such association in the Texan Permian, as well as in the Productus limestone of India, shows conclusively that certain Mesozoic types began their existence long before the close of Paleozoic time. Such forms in such association may be properly regarded as harbingers of an approaching, but not yet established, Mesozoic era, because, in this case at least, the balance of paleontological evidence favors their reference to the Paleozoic. Such facts as those which have been mentioned, as well as others presently to be referred to, indicate that upon the confines of epochs, periods and ages of geological time there was always a commingling of types of then living forms which in their culmination were characteristic of each of those chronological divisions respectively. Furthermore, I shall call your attention to evidence that some of the types which especially characterized certain geological periods survived in full vigor through later periods. But let us return to a consideration of the Mesozoic rocks.

Those rocks of the great Interior region which have by common consent, but upon comparatively slight evidence, been referred to the Trias, are found upturned against the flanks of the Rocky Mountain, and other ranges, and exposed to view in the valleys and cañons of the Plateau province. They reach several thousand feet in thickness, and are so nearly uniform in color and lithological character over the whole of the great area within which they occur that they are often designated as the "Red Beds." They are found resting upon rocks of different age in different places, but in some districts they rest with apparent conformity upon a series of sandstone strata which are probably of Permian age.

This formation is apparently of non-marine origin and, as a rule,

it is quite barren of fossils. The few molluscan remains that have been obtained from it give no indication as to its age and, in the light of present knowledge, the few plant and vertebrate remains obtained from it are far from satisfactory in this respect. Still, it is not my object to deny the Triassic age of this formation, but only to call your attention to the fact that paleontological evidence upon this point is very meagre.

Because of the paucity of fossils in both this formation and in the reputed Permian upon which it rests in different districts, little is known of any paleontological relationship between them. There are, however, some indications of such relationship that deserve mention. The case of the commingling of Mesozoic and Paleozoic types in the Permian of Texas has already been stated. Another case in South Park, Colorado, may be mentioned, and the possible occurrence of still another in southeastern Idaho may be suggested.

Important collections of plants and insect remains have been obtained from certain strata in South Park which are reported as immediately overlying rocks of unquestionable Carboniferous age. The plants are regarded by Professor Ward as constituting the most characteristic Permian flora that has been found on this continent. The stratigraphical relation of these rocks is also suggestive of their Permian age; and yet Mr. Scudder referred the insects to the Trias without qualification.

Some years ago Dr. Peale discovered in southeastern Idaho an unique assemblage of fossils in strata which rest conformably upon the Carboniferous and evidently occupy a position beneath the Triassic Red Beds, which occur in the same neighborhood. A part of the species belong to the Ammonitidæ and a part to the Ceratitidæ; and upon the evidence of these cephalopods Professor Hyatt referred the strata bearing them to the Middle Trias of Europe. When one remembers that cephalopod forms similar to those just referred to occur in India associated with a characteristic Carboniferous fauna, he naturally inquires whether it is not possible that the Idaho strata ought to be referred to a period not later than the Permian.

Those Idaho strata and the South Park and Texan Permian all possess great interest as indicating an intimate relationship between the Mesozoic and the Carboniferous of the Interior region; and if the record between the Paleozoic and the Mesozoic had not

been so generally and so badly broken on this continent, we should doubtless now find many similar and more complete cases of the commingling of earlier and later types.

Some American field geologists have privately, if not publicly, expressed the opinion that the Permian ought to be assigned to the Mesozoic, rather than to the Paleozoic; but notwithstanding the paleontological relationship that has just been mentioned, such a view is untenable when all the known facts are considered. It is at present sufficient to say that the great break between the Mesozoic and Paleozoic of North America occurred while yet Paleozoic forms of life were far in excess of Mesozoic forms; and that almost all the North American strata that have been recognized as of Permian age appear to have been the result of continuous sedimentation from the Carboniferous. In short, all the hitherto recognized or reputed Permian of North America is far more intimately related both paleontologically and stratigraphically with the Paleozoic than with the Mesozoic. Therefore the lower delimitation of the North American Mesozoic must coincide with the base of the lowermost discovered Triassic strata.

A few hundred feet in thickness of strata, which have by common consent long been referred to the Jurassic, are found within a large part of the middle portion of the Interior region, resting conformably upon the Triassic strata which have already been noticed. Where these Jurassic strata have been fully studied, especially in Colorado and Wyoming, they are separable into an upper and a lower portion, the lower portion being of marine, and the upper, of fresh-water origin. The invertebrate fossils of the upper portion are mostly of types that are now living and are, therefore, of no value as indicating their geological age. Those of the lower portion are few, and the cephalopods only, or mainly, present such characters as to suggest their Jurassic age; and it was upon this slight evidence, together with the relative position of the strata, that their reference to the Jurassic was first made.

Professor Marsh's well known publications of the remarkable dinosaurian faunas from both the upper and lower portions of the strata in question have left no reasonable doubt that they are really of Jurassic age. Professor Marsh refers all these strata to the Upper Jurassic of Europe; and in connection with this statement I wish to call your attention to the fact that wherever they have been found in contact with the Triassic strata already dis-

cussed, they are not only strictly conformable, but they seem to have been the result of continuous sedimentation. In fact, it is paleontology alone that suggests an hiatus between them. The field geologist finds no evidence of it.

The Jurassic rocks of the Interior region disappear both to the northward and southward, their geographical range being apparently a little less than that of the underlying Triassic beds. No equivalent of the former has been found in Canada, although the Cretaceous Dakota Group, which immediately overlies the Jurassic further southward, has been recognized there. It may be remarked also that where the Jurassic is not present beneath the Cretaceous, the latter, especially in the eastern part of the region, is often found resting directly upon the older rocks, sometimes even upon the Archæan. In Texas the Jurassic is also absent from beneath the Marine formation, which is regarded as the representative of the Dakota Group there, the latter resting directly, but unconformably upon the Comanche beds, to be presently noticed.

Omitting present consideration of the isolated masses of reputed Jurassic rocks in western Nevada and eastern California, this subdivision of the Mesozoic seems to be represented in North America mainly by the slight accumulation of strata in the Interior region which has just been noticed. We know little or nothing of the flora which existed when these strata were deposited; their invertebrate fossils are of little value in determining their geological age, and if it were not for their dinosaurian faunas their Jurassic age might well be questioned.

The section of the Cretaceous formations which prevail in the central portion of the Interior region, and to which I shall more particularly refer in following remarks, differs materially from a similar section in the southern portion, usually known as the Texas section. Meek & Hayden divided the Cretaceous of the central portion of the region into the Dakota, Benton, Niobrara, Pierre and Fox Hills groups, the first mentioned being the earliest and the last one mentioned, the latest. In Texas, the Cretaceous section is continued much beneath the equivalent of the Dakota Group there. These lower Texan strata constitute the important marine formation now known as the Comanche beds, the molluscan fauna of which gives peculiar paleontological character to the Texan section. Above the Comanche beds there is a series of formations that are understood

to respectively represent all the more northern formations which have just been mentioned.

After due consideration of all the known facts, some of which are of recent acquisition, there seems to be no room for reasonable doubt that the marine Cretaceous deposits of the Interior region which are later than the Dakota Group are, as a whole, not only equivalent with the marine Cretaceous deposits of the Atlantic and Gulf Coast region, but that they were all originally continuous through the whole of that great geographical extent. These formations are too well known to need present characterization; and they are now known to constitute the most extensive and definite taxonomic horizon that has been recognized among the Mesozoic formations of this continent. Furthermore the marine molluscan fauna of these strata is of such a character as to leave little room for doubt that they represent homotaxially the Senonian, and perhaps a part of the Danian, of Europe. The difficulty, however, of accurately correlating the Cretaceous formations of this continent with those of Europe is very great, as has, for example, lately been indicated by Professor Rœmer's reference of certain fossils of the Comanche beds to the Upper Turonian. These beds lie wholly and unconformably beneath the horizon of the Dakota Group which is itself not probably newer than the Cenomanian.

Before proceeding to a consideration of the Laramie Group it is proper to say that the presence in British America of the Kootanie formation beneath the Dakota Group, and that of the Comanche beds beneath the equivalent of the latter in Texas, shows that there is really an hiatus between the Dakota and the Jurassic in the Interior region, although their conformity is so complete that it has never been detected by field observation. If a similar hiatus exists between the Jurassic and Triassic in the same region, we have also no stratigraphical evidence of it.

The Laramie is in many respects one of the most remarkable of the North American formations. It is found occupying large portions of the Interior region from the state of Nuevo Leon in Mexico to beyond north latitude 52.° It reaches a maximum thickness of nearly 4000 feet in Colorado, and more than that in British America. It is not only everywhere conformable upon the Fox Hills Group, but wherever the junction between them has been seen sedimentation from the older to the later formation appears to have been continuous.

In all its great geographical extent the Laramie Group has never been found to contain any animal remains similar to those which inhabit the open sea only. A considerable proportion of its invertebrates are like those which are now denizens of brackish waters, and a still greater proportion are fresh-water forms. It is mainly upon this abrupt change from a marine to a brackish- and fresh-water character of the molluscan fossils, and not upon stratigraphical difference, that we rely to determine the lower limit of the Laramie formation.

The labors of Dr. G. M. Dawson and Mr. Whiteaves, and their associates in the Canadian Survey, have shown that conditions similar to those which gave character to the Laramie formation existed in a large part of the northern interior region long before the close of the Fox Hills epoch, and that they were probably continued into the Laramie epoch. But time will not permit me now to discuss this interesting question.

Besides the invertebrate fauna which has just been referred to, a few insect remains, a rich flora and a somewhat extensive and varied vertebrate fauna have been obtained from the Laramie formation. None of the molluscan remains, so far as I can judge, possess characters which any similar forms might not have possessed at any time from the Middle Cretaceous to the Eocene inclusive; and a large part of them differ from living forms only as species.

Similar remarks may be properly made concerning the plant remains of the Laramie formation. Professor Ward has shown that of the one hundred and twelve genera of plants which have been discovered in the Laramie, thirty-eight of the genera and five of the species are common to the Dakota Group; eighty-five of the genera are living and twenty-seven are extinct. These extinct genera are all so nearly allied to living genera respectively that it is difficult to separate them. Furthermore, not less than three species from the upper strata of the Laramie have been identified with living species.

Mr. Scudder has referred the insect remains to the Tertiary, but the vertebrate remains, especially those of mammals and land reptiles, are of more ancient types than those of the plants and invertebrates. Among the few Laramie mammals that have been discovered there is no indication as to the ancestry of that great mammalian fauna which characterized the immediately following Wasatch period. The reptiles are mainly Dinosaurs of Cretaceous

types, but some of them seem to possess characters that suggest their Jurassic age.

Some paleontologists have long hesitated to give an opinion as to the true taxonomic position of the Laramie Formation; but those who have studied the vertebrates only have usually referred it unqualifiedly to the Cretaceous, apparently assuming that, containing dinosaurian remains, it could not be of later age. Field geologists, especially those who practically ignore paleontological evidence, also refer the Laramie to the Cretaceous, because of its intimate stratigraphical relation to the marine Cretaceous beneath it, and because in all the principal displacements, which the latter has suffered in the Interior region, the Laramie was equally involved.

The formations which overlie the Laramie were, by common consent, long regarded as of Tertiary age; but concerning the age of some of them, differences of opinion have since arisen. Between the Laramie and any overlying formation there is often, but not always, unconformity. In Utah, and apparently in the valley of the Lower Yellowstone also, I have found the Laramie passing gradually up into purely fresh-water deposits without any stratigraphical break. In the former case I am sure, and in the latter case I believe with Professor Newberry, that the upper strata represent the lower part of the Wasatch Group.

In Utah several of the fresh-water molluscan species, which are widely distributed in the Laramie, are found to have passed up into the Wasatch; thus confirming the stratigraphical evidence of the immediate succession of the Wasatch upon the Laramie. In southern Wyoming dinosaurian remains are found in some of the uppermost strata of the Laramie; and the lowermost Wasatch strata in the same region bear Coryphodont and other placental mammalian remains; but remains of these two orders have never been found commingled. Still, in view of the facts just stated, it is not possible to doubt that those placental mammals lived contemporaneously with at least the last of the Laramie Dinosaurs.

In northwestern New Mexico and southwestern Colorado, Professor Cope has found certain strata at the base of the Wasatch. and overlying the Laramie, to contain the remains of a peculiar vertebrate fauna whose distinguishing members are placental mammals which are quite different from those of the Wasatch. These strata he designates as the Puerco Group, and he now refers them, together with the Laramie, to the Cretaceous, because of certain char-

acteristics which the Puerco mammalian and reptilian remains present; but he formerly regarded that group of strata as of Cenozoic age. These Puerco strata have the appearance of having been deposited simultaneously with those which elsewhere constitute the lower portion of the Wasatch Group; and before their vertebrates were studied by Professor Cope their identity with the Wasatch was not questioned.

But we are not yet done with Dinosaurs. Mr. George H. Eldridge has lately shown that in the vicinity of Denver, Colorado, there is a distinct formation, from 600 to 1200 feet in thickness resting unconformably upon the Laramie, which he has called the Arapahoe formation. Mr. Whitman Cross has also lately shown that still another formation in the same district, having a maximum thickness of more than 1400 feet, rests unconformably upon both the Arapahoe and Laramie formations. To these strata he has given the name of Denver formation. The great aggregate thickness of these formations, together with their respective displacement with relation to the Laramie and to each other, shows that much time must have elapsed between the deposition of the uppermost Laramie strata in that district and the uppermost Denver strata.

Mr. Cross shows that a large part of the plant remains, which have been reported as coming from the Laramie in this district, really came from the Denver formation. Some of the fresh-water mollusca of the Denver strata I am not able to distinguish from Laramie species. But the most unexpected fact of all which these gentlemen have brought out is that both these formations above the Laramie contain dinosaurian remains in comparative abundance. The skull in some species is found to bear a pair of horns similar in posture and shape to those of the hollow-horned ruminants. Some of the bones also present characters which are suggestive of earlier Mesozoic age; but in a general way, at least, these Dinosaurs are similar to those of the Laramie.

The Laramie Group does not reach its maximum thickness in the Denver district, and it is not known whether the latest Laramie strata are represented there. Both the Denver and Arapahoe formations are of limited extent, and it is quite probable that the latter, and perhaps the former, together represent the later portion of the Laramie period. But it is reasonable to infer that at least the later portion of the Denver formation was contemporaneous with the earlier fresh-water Eocene strata of the Green River basin,

notwithstanding the fact that the former bears dinosaurian remains.

The present state of our knowledge seems to justify us in regarding the marine Cretaceous formations immediately beneath the Laramie as representing the Senonian of Europe, perhaps including even a part of the Danian. Now if we add to the American Cretaceous the Laramie, Arapahoe and Denver formations, we evidently extend the Cretaceous in America much beyond its recognized latest limit in Europe.

But why, we may ask, should not those Dinosaurs have survived from Mesozoic, into Tertiary time? Why should they not have continued their existence as long as physical conditions were favorable, and as long as they could compete in the struggle for existence with such mammalian faunas as that whose earliest known history is recorded in the earlier strata of the Wasatch formation?

Before summarizing the conditions of the Mesozoic of the Interior region and proceeding to a consideration of the Pacific Coast section, I wish to refer to the relation of the Laramie Group with the marine Tertiary of the Gulf and the Atlantic coasts.

For reasons presently to be mentioned, no direct stratigraphical proof of contemporaneity of our great fresh-water inland deposits with marine coast deposits is possible, and direct paleontological proof is not to be expected. I had long hoped, however, that because the Laramie Group was in part of brackish water origin its continuity or contact with some marine coast deposit might be discovered. Such a discovery was first announced by Professor Cope, which I afterward confirmed and showed that in the vicinity of Laredo, Texas, the Laramie Group as a whole underlies with apparent conformity marine strata which contain an abundance of *Cardita planicosta* and other characteristic Eocene fossils; but I was not able to detect the continuity of the Laramie with any sea coast formation.

It was this discovered relation of the Laramie to the Gulf Coast Eocene that was referred to by the suggestion in a previous paragraph that there is really an important hiatus, although apparent conformity, between the Cretaceous and the Tertiary deposits of the Atlantic coast. The Gulf Coast Eocene just mentioned being regarded as equivalent with that of the Atlantic Coast, and the uppermost marine Cretaceous immediately beneath the Laramie, as equivalent with the uppermost marine Cretaceous of the Atlantic

Coast, it follows that the hiatus referred to equals the whole of the Laramie. It may also be mentioned in passing that, both upon stratigraphical and paleontological evidence, I regard both the Northern Lignitic of Hilgard in Mississippi and its equivalent in eastern Texas as equivalent with the upper, lignite-bearing, portion of the Laramie as it occurs in the valley of the Rio Grande.

Very briefly summarizing the Mesozoic of the Interior region we find that its lower delimitation is greatly lacking in uniformity, the lowest member being sometimes the Triassic, sometimes, but rarely, the Jurassic, and sometimes the Cretaceous. The Triassic apparently represents the upper Trias of Europe, the Jurassic, the Upper Jura, and most of the Cretaceous, the upper part of that subdivision of the Mesozoic. Above the marine Cretaceous strata, inland sea and lacustrine deposits were continued into Tertiary time, apparently without a break, either paleontological or stratigraphical.

Having to deal with extensive inland deposits alone when investigating the immediate relation of the Mesozoic to the Cenozoic in the Interior region, we find that the most direct means of determining such relationship is wanting, because the continuity of the marine paleontological record is broken at the base of the Laramie formation. Still, the opinion that we have a continuous record there from Cretaceous, into Tertiary time, is strongly supported by paleontological and stratigraphical evidence. But we come now to consider the Mesozoic of the Pacific Coast region, where we shall find proof of unbroken continuity of marine deposits from the Upper Cretaceous to the Tertiary. Time will not permit me now to discuss the Mesozoic of western British America which Dr. G. M. Dawson, Mr. Whiteaves and other Canadian geologists have done such excellent work upon, and I must therefore confine myself mainly to the California section.

The rocks of this portion of the Pacific Coast region have been so greatly displaced since their deposition that their study is more difficult than that of the rocks of the Interior region. Still, our knowledge of the upper part of the Pacific Coast Mesozoic is quite satisfactory. The oldest Mesozoic strata of the California section which I shall specially refer to on this occasion were, by the California geologists, assigned to the Lower Cretaceous, under the name of the Shasta Group. But these strata do not probably represent the very earliest part of the Cretaceous period.

The exact relation of the Shasta Group to the Cretaceous forma-

tions above it has not yet been made clear; but Mr. Diller's investigations in northern California seem to indicate that the hiatus between them is not so marked as has been supposed. The geologists of the California Survey did not recognize any formation as belonging between the Shasta and Chico groups, but Dr. G. F. Becker has reported upon a series of strata in Mendocino county which he believes to be later than the Shasta, and earlier than the Chico. Upon examining the fossils which he collected from those strata, some of the species of which have also been found at Todos Santos Bay in Lower California, I concurred in his opinion and suggested for those strata and their equivalents the name of Wallala Group. Still, actual contact of this group with any other Cretaceous strata has not yet been discovered, and its actual taxonomic position is not known.

From the base of the Chico Group upward the series of California strata which has been referred to the Cretaceous is so well known that little if any difference of opinion exists as to essential facts concerning it, although a wide difference of opinion has arisen as to their significance and importance. This series, aggregating more than ten thousand feet in thickness, was divided into two groups by the California geologists, namely the Chico below and the Téjon above, although they recognized the fact that there is no distinct break, either paleontological or stratigraphical, between them.

A considerable number of fossil invertebrates, among which are a species of Baculites and several ammonitic forms, constitute such a decided Mesozoic feature of the fauna of the lower portion of this Chico-Téjon series that the California geologists naturally and properly referred it to the Cretaceous. The upper, or Téjon portion contains a fauna that is so obviously Cenozoic in character that several geologists, especially Heilprin and Conrad, have strenuously contended that it is of Eocene age. A large proportion of these Téjon species are found to be so common in the Chico portion that if they were not there commingled with the Cretaceous forms just referred to, the Tertiary age of those lower strata would hardly be questioned. In short, there is in this stratigraphically unbroken Chico-Téjon series of California, a gradual transition of faunal characteristics from the Cretaceous to the Tertiary.

This transition was recognized by Mr. Gabb, and yet he referred the whole series to the Cretaceous. His view was that, a portion

of the series being assigned to the Cretaceous, the remainder of it must follow, because the series can only be arbitrarily divided; and other geologists still entertain a similar opinion. By whatever name or names this great series of strata may be known, it is plain that it represents a continuous portion of geological time extending from the later Mesozoic, to the earlier Cenozoic age inclusive. Therefore the Mesozoic series of strata in this portion of the Pacific Coast region has really no definable upper limit.

It is true that by our present methods it is inconvenient to classify a series of strata like this, but the recognition of its true character is of far more importance than mere convenience of classification. Indeed this case constitutes one of the most instructive discoveries that has been made in the whole range of historical geology; and it should be understood as demonstrating that abrupt transitions from one epoch, period or age to another have always been due to local or regional changes in physical conditions; or in other words, to accidental circumstances.

Concerning the relation of the other members of the California section of the Mesozoic to the Chico-Téjon series, or to each other, and the relation of the lowest of those formations to the Jurassic, our knowledge, as before mentioned, is imperfect.

The satisfactory correlation of a part of the Cretaceous formations of the Interior region with those of the Atlantic Coast region has already been mentioned; but we have never been able to satisfactorily correlate any of the Cretaceous formations of the Pacific Coast region which have been mentioned, with any of those of the Interior and Atlantic Coast regions, even in cases of presumable contemporaneity. If such correlations are ever made we must expect them through the labors of the Canadian geologists in the Northwest. The whole fauna of each of the Pacific Coast formations referred to seems to be different from that of any of the more eastern formations, the few cases in which specific identity has been recognized being of doubtful character. This inability to correlate formations in different and not far distant parts of our own continent, which were presumably contemporaneous in their origin, may well cause us to doubt the correlation of at least a part of the American formations with those of other parts of the world which various authors have confidently assumed.

It has already been shown that the lower limit of the North American Mesozoic must coincide with the lowermost Triassic

strata in any given section, whether those strata are regarded as representing the earlier or the later Trias; and that no strata hitherto recognized as Permian can be reasonably referred to the Mesozoic That is, the lower limit is defined by a great break in the geological record of this continent, constituting an hiatus, which began before the full completion of Paleozoic time and continued until after the beginning of Mesozoic time.

But we are quite unable to designate clearly the upper limit of the Mesozoic in at least a large portion of this continent. It is true that in the Atlantic Coast region the upper limit of the Mesozoic is clearly marked where the marine Eocene rests upon the uppermost of the Cretaceous strata there, but that delimitation is produced by an hiatus. In portions of both the Interior and Pacific Coast regions, however, it is quite impossible to clearly designate the delimitating boundary between the Mesozoic and Cenozoic, because in at least a part of both regions no break in either the stratigraphical or paleontological record occurred until after Cenozoic time was fully established.

In connection with the foregoing brief summary of the characteristics of the North American Mesozoic, certain views have been expressed which I entertain in common with some, but not all, other geologists concerning the correlation of formations and the interrelation of presumably contemporaneous fossil faunas and floras. The following propositions are offered as the basis of those views. A part of them, however, will not be questioned by any geologist, but these are given with the others for the sake of relevancy.

(1). In accordance with the principles of modern biology we must conclude that although it has not been demonstrated by actual discovery, there has been a continuous genetic succession of living organisms upon the earth ever since life began. That is, while numerous breaks in that succession have occurred, they have never been of universal, but only of local or regional extent; and they have been due to similarly restricted physical changes.

(2). The record of that succession of living organisms has been accomplished and preserved by the natural entombment of their fossilizable remains in aqueous sedimentary deposits. Subsequent physical changes have destroyed or rendered inaccessible a large part of the record, and all we know of that succession is derived from such of those remains as we have been fortunate enough to discover.

(3). The record of the succession of terrestrial life has been far less complete, and has suffered greater interruptions, than that of aqueous life, because the record of the former has been made under conditions which were irrelevant, or inimical, to that life, and the entombment of its remains has always occurred under accidental conditions.

(4). The record of marine life is necessarily more complete than that of any other because the seas have furnished continuous, and more uniform, conditions than either the land or fresh waters, and because the preservation of its remains was a natural consequence of the conditions under which that life existed. Therefore the record of marine life was less modified by other than evolutional changes of a cosmical character than that of the land and fresh waters, and it is consequently more trustworthy as an index of the progress of geological time.

(5). Breaks or interruptions in the succession of marine forms of life have been coincident with breaks of continuity, or with changes in the characters of the sediments by which their remains were entombed. These breaks in sedimentation, and in the succession of living organisms, are used by all geologists as indicating the delimiting boundaries of geological epochs, periods and ages respectively; as well as of formations and systems. Their causes were independent of the existence of life, and their occurrence was accidental with reference to it.

It therefore follows that the recognizable time record in one part of the world is necessarily different in its divisions from that of any other part. For example, a period, the close of which was marked by such interruptions as have been mentioned in one part of the world would be continued in other parts as long afterward as the occurrence of similar breaks there should be postponed. While such interruptions were occurring in one or more parts of the world, life and sedimentation were continuous and unaffected by them in others. This is plainly shown in the case of the Chico-Téjon series in California, because no inter-delimiting boundary occurs between its Cretaceous and the Tertiary portions, as has already been explained; while an evident hiatus exists between the uppermost known Cretaceous and the lowermost known Tertiary both in Europe and a large part of North America.

(6). While there has been progressive development in the order of succession of living organisms from lower forms in earlier, to

higher forms in later geological time, the rate of progress of that development has not been uniform in all parts of the world for the same kinds of life. For example, the plant life of North America is now understood to have reached, in later Mesozoic time, a higher stage of development with relation to animal life than it had in Europe; and the difference in grade among the now living indigenous faunas of the different continents respectively, indicates that a similar difference in the rate of development has also prevailed in different divisions of the animal kingdom.

(7). The various stages of progressive development of living organisms have been marked by the successive introduction and extinction of class, ordinal, family and generic types; and yet certain of those types survived in some parts of the world during long epochs after they had become extinct in other parts. This proposition is supported by such facts as that of the survival into the Laramie, Arapahoe and Denver epochs, of dinosaurian faunas which apparently show little if any indication of decadence or of approaching extinction; and also by the survival of highly organized representatives of Mesozoic families and genera to the present time. Therefore it is not to be expected that we should find exactly the same association of faunal and floral types; or evidence of more than approximately the same grade of development of life in contemporaneous, but widely separated formations. Therefore also, the custom which has been adopted by some paleontologists of making the assumed absence of certain of those types a distinguishing element in the chronological diagnosis of formations is by no means to be commended, even if it were possible for us to discover remains of all the forms of life which then and there existed.

(8). Correlation of lake and inland sea deposits with those of open sea origin, even within the same continental area, is necessarily a matter of uncertainty. This uncertainty is due to the great difference in the character of the faunas of those waters respectively, to the fact that constituent members of faunas of inland waters were not so diversely differentiated in the course of geological time as were those of marine waters; and also the inevitable want of geographical continuity of the two classes of deposits with each other, even in cases of actual contemporaneity. The only really trustworthy paleontological means of determining the equivalency or contemporaneity of deposits in such cases as these is the specific identification of such remains of land animals and plants

as may have found entombment in then existing contiguous inland waters on the one hand, and marine waters on the other. For reasons mentioned in proposition 6, the mere similarity of types, even of the more highly organized animals and plants, which may be discovered in different districts cannot be relied upon as indicating contemporaneity. Geographical continuity of strata being always wanting in such cases the only aid to be expected from stratigraphy in determining equivalency of the formations must come through the discovery of the overlying or underlying position of the inland deposits with reference to marine deposits of known geological age.

It will be seen that these propositions involve serious questionings of the validity of certain methods and practices common among many of those geologists who devote themselves mainly or exclusively to paleontology. Such questionings afford scope for elaborate and varied discussions, but I shall close my present remarks with only a brief reference to the general subject of a proper recognition of a universal scheme of geological classification, which must of course have a biological basis.

The greater part of my own geological studies having been prosecuted from a biological standpoint, I am naturally not disposed to underestimate the value of paleontology as a branch of geological investigation, nor to encourage, even by incidental utterance, those who do. But I am sure no greater harm can be done to paleontological science than either to encourage, or to fail to oppose, the erroneous views which some of its votaries are shown by their own publications to entertain. For example, it is apparent to every one who is at all familiar with paleontological literature that many authors assume to designate with precision the geological age of any and all fossils submitted to them, as well as the taxonomic position of the strata from which they were obtained, without reference to stratigraphy, or to any related geological fact.

Those paleontologists who make this unwarranted application of their science to systematic geology, all use the scheme of classification that has been established for Europe, and use it as if it were of infallible application to all other parts of the world, and also as if it were already absolutely perfected for that continent. While I have no inclination to question the general accuracy of the European scheme of classification for that continent, I do not hesitate to express the opinion that it is not of infallible application

to other parts of the world, except as to its larger divisions, and that even in this respect it will need modification. That is, I hold that investigation of the formations which are found upon any given continent or great division of the earth's surface ought to be prosecuted first, with relation to one another, and second, with reference to their ultimate, not immediate, correlation with those of other continents or divisions.

It is true that the general consensus of geological thought and opinion has long been in favor of adopting the European scheme of classification in all, or nearly all, its details as applicable to all other parts of the world, and every considerate naturalist will treat such opinion with deference. But prevalence of opinion is by no means proof of its accuracy. None of the older naturalists present need be reminded of the great revolution in opinion that took place a little more than twenty years ago; and the older geologists will remember that the degree of displacement, the amount of consolidation, the crystallization and lithological composition, of strata, were once accepted by all geologists as indices of the geological age of the formations which they composed. Remembering these incidents in the history of natural science it does not seem unreasonable that present opinions should be frequently questioned, even those which are generally accepted.

I do not wish to be understood as condemning the scheme of classification now in use, nor even as recommending the present substitution of it by any other; but I insist that for universal application, it is plainly imperfect. A scheme of classification, as a working rule, is not only a convenience but a constant necessity; so constant indeed that I have not been able to present these remarks without its aid. But while the one which has been established for Europe ought by no means to be discarded, it ought to be used tentatively in each of the great divisions of the earth, and with reference to the ultimate establishment of a universal scheme after all those divisions have been thoroughly investigated.

The time has come when North American geologists can, and ought to, hold a commanding position in this respect; and when we have elaborated a scheme of classification for the formations of our own continent, it will have equal claim to the favorable consideration of the geological world with any other.

PAPERS READ.

THE ORIGIN OF GNEISS AND SOME OTHER PRIMITIVE ROCKS. By DR. ROBERT BELL, Assistant Director of the Geological Survey of Canada, Ottawa, Canada.

[ABSTRACT.]

GNEISS being probably the most abundant rock in the crust of the earth, it is rather singular that geologists have not yet come to a general agreement as to its usual process of formation. I say usual, for gneissoid rocks may be formed in more ways than one. For example, the granitic materials of some dykes are occasionally found to have assumed a gneissoid foliation parallel to the walls of the dykes, but no one would pretend that this was the normal mode of formation of the continuous gneiss of half a continent.

It is conceivable that a gneissoid, or rather a streaked, appearance may have been developed in certain granitic or syenitic rocks by a flowing movement, while in a plastic state, but such an appearance would, I think, be only very limited and would differ from ordinary gneissic bedding. The parallel mottling or clouding and isolated patches of a gneissoid character sometimes met with in granite or syenite may even be accounted for in other ways than from flow motion.

The bedding of gneiss differs from the streaking of slags by flowing, in being in continuous sheets which generally differ much in composition as well as color. It is difficult to imagine how flow-structure could communicate a distinctly and uniformly bedded arrangement throughout a depth of about ten miles of strata which is the ascertained thickness of one section of the Upper Laurentian alone. The presence of enormous beds of limestone, traceable continuously for a hundred miles or more, in the midst of these gneisses appears to me to be fatal to the flow-structure theory. Pressure will not account for the bedding of the Laurentian rocks, for no amount of pressure would separate a homogeneous mixture into distinct beds consisting of the different minerals. Or if pressure could separate these constituents, why have certain areas remained as granite or syenite?

The composition of different superimposed beds of gneiss often differs greatly, some being highly micaceous, while this mineral is scarce in others lying above or below. Again, considerable thicknesses may consist almost entirely of felspar, quartz or hornblende alone. I might mention in passing that hornblende is a very abundant constituent of our

gneisses — hornblende-gneiss being about as common as the so-called typical or mica-gneiss. Now a fused mixture of materials would not separate into layers of the different ingredients, and certainly not into such innumerable fine layers as make up the immense thicknesses of these gneisses. This is, I think, another fatal objection to the above theory. Then some of the bedded rocks of the Laurentian system bear such a close resemblance to or may rather be said to be identical with rocks which we can trace to a clastic and even sedimentary origin, that we are forced to conclude that they too have had a similar origin.

The Upper Laurentian rocks are differentiated into belts or groups of beds which can be traced over considerable distances on the ground and can thus be accurately mapped. After carefully working out a large area in this way Sir William Logan proved that the Upper Laurentian strata obey the ordinary structural laws governing stratified rocks when thrown into anticlinal and synclinal folds.

The lower Laurentian gneisses cannot be so easily separated into distinct belts, and limestones appear to be absent from this division, but many of them resemble the gneisses of the upper series so closely that it is altogether likely they had a similar origin. The lower Laurentian strata are more contorted and at the same time more solid or massive than the upper. They also occupy a much larger geographical area. In Canada the Upper Laurentian appears to be confined to a comparatively limited region extending from Georgian Bay eastward through the Ottawa valley and along the north side of the St. Lawrence. It also occurs in eastern Labrador and perhaps in Hudson's Strait.

In the country stretching from Lake Huron to Lake Temiscaming at the great bend of the Ottawa, and thence northward and in other directions, we have the best known and one of the largest areas of Huronian rocks in Canada. Having worked on these rocks for a number of years, I have had good opportunity for studying them and I beg to offer a few suggestions based on these observations, as to the origin of gneiss and some other primitive rocks.

In the region referred to we have vast quantities of a rock of which very little has hitherto been said by geologists. The late Mr. Alexander Murray mentioned certain varieties of it under the somewhat erroneous name of slate conglomerates. It is a grey or ash colored rock somewhat resembling sandstone, but usually massive or not separated into distinct parallel beds. It bruises readily under the hammer and may be easily broken or scratched, showing that it is largely composed of softer material than quartz. This rock as a matrix often contains large numbers of angular and rounded fragments of all degrees of coarseness from the size of pins' heads to that of pease, walnuts, a man's fist and even boulders. They consist for the most part of reddish quartz-felspar rock, granulite or binary granite, but fragments of other rocks occur in some varieties.

In the specimens which I have examined under the microscope the matrix is seen to consist principally of angular grains of felspar and rounded grains of quartz with a darker amorphous mineral filling the interspaces.

Much of this rock might be called a volcanic ash or breccia. The portions which are most free from pebbles or fragments are like the gold-bearing "whin-rock" of the Nova Scotia miners. Some of it might be called sandstone, and much of it passes by insensible degrees into quartzite. It is, however, desirable to have a general name for this rock and I know of no single word which will better describe it than greywacké. Now this greywacké seems to me to be the raw material out of which some of the other Huronian rocks of this region have been formed. And from a study of the transformation of one rock into another I have come to the conclusion that the origins of several kinds of crystalline rocks have points in common and are mutually dependent on one another in a larger measure than we may have supposed. Thus if we can account for the origin of gneiss we shall have incidentally accounted for that of some other crystalline rocks at the same time.

Another rock which is very common in some parts of the area referred to is quartz-diorite. It presents considerable variety of conditions with the same constituents, passing from the purely crystalline kind through several stages less or more modified by water, as if it had flowed out under the sea and been variously affected by the water according to the volume of the rock-matter present; or in other cases it seems to have been entirely broken up and modified by the sea, the constituents without the addition of anything else resulting in an aqueous deposit. The quartz-diorite is another parent from which some of the other Huronian rocks are derived.

But to return to the greywacké, there are plenty of examples in this region which show that it passes directly into different varieties of quartz-syenite and gneiss and also that these rocks, as well as quartzites, clay-slates and dolomites may be derived from it.

In the direct formation of gneiss the materials of the more slaty varieties of the greywacké in some cases appear to separate somewhat into laminæ by a process of segregation. In other cases they gather themselves into grains or spots by a species of concretion. The complete conversion of these into finished gneisses is effected by a slightly further alteration through the agencies (whatever they may have been) which have produced the metamorphism of the crystalline rocks in general.

On the other hand the more massive varieties of the greywacké may be seen to change gradually into imperfect and then perfect or thoroughly crystalline quartz-syenite. The process seems to be largely due to concretionary action, both on a small and large scale.

The breaking up and modification of the materials of the greywacké by water appear to give rise to a great variety of quartzites on the one hand, and to clay-slates on the other. These materials may have been thrown into the sea either as mud or dust and become separated and deposited at once in different places as quartz-sand and clay, or the rock, after partial or complete consolidation, may have become broken up and reduced by the action of water so that the quartzose and the argillaceous portions could become separated and each deposited by itself, to form the quartzites and

clay-slates, which almost always accompany each other, as well as the greywackés of this region. The very fact of the association of these rocks suggests a connection of all these or a dependence of the quartzites and clay-slates upon the greywackés. The clay-slates frequently have layers of hornblende developed in them parallel to the bedding.

The quartzites are often largely mixed with the softer material of the greywacké, being in these cases merely the more silicious varieties of this rock which pass by insensible degrees into ordinary quartzite. The quartzite, however, is never entirely free from disseminated particles of felspar and this mineral in a crystalline form may be present in all proportions up to nearly half the whole mass.

These crystalline grains of felspar are generally light red in color and on very old surfaces they become dissolved out leaving little holes or pits. On slightly weathered surfaces they assume an opaque white, contrasting with the vitreous lustre of the quartzite, so that these surfaces have a speckled appearance. Where the felspar is uniformly and thickly scattered through massive quartzite, the rock is really a quartz-felspar or binary granite except that it has not yet become entirely crystalline but this change might readily be accomplished in time.

Where the felspar grains are disposed more thickly in rows in cross section, the rock looks very like gneiss even to the naked eye, and still more so under the microscope; and it might be converted into this rock by more complete alteration. On the west side of Lady Evelyn Lake between Temagami Lake and the Montreal River there is a mountain ridge 1,100 feet high, largely composed of this rock, standing nearly on edge, which a casual observer might easily take for gneiss although on closer examination it may be seen to be of clastic nature. The quartzite beds or quartzose gneisses of the Upper Laurentian in the county of Ottawa often contain felspar grains or crystals which weather out just like those of the Huronian quartzites and the outward appearance of the two rocks is so similar that hard specimens could not be distinguished from each other.

The curious varieties of modified quartz-diorite which have been mentioned are very abundant in some parts of the region under consideration —notably in the township of Denison. Extensive sections may be seen made up of beds of different thicknesses, but mostly thin, in each of which the quartz grains and the other components have been roughly separated from each other by the action of water. The bottom of each bed consists almost entirely of rounded grains of quartz; but, as we ascend, these become more and more mixed with argillaceous material till at the top there is pure clay-slate. The same arrangement is repeated in all the beds. In the vicinity of these beds there are others entirely of quartzite and of clay-slate, which I believe owe their origin to the disintegration of the quartz-diorite (probably when in a soft condition) and the separation and transportation of the original ingredients by water. If the thin alternating layers of quartz grains and slaty material were completely metamorphosed they would result in gneiss. The rocks of this region therefore appear to show three ways by which gneiss may be formed, namely,

by the direct conversion of the thin bedded or slaty varieties of greywacké, the alteration of the mixed quartz and felspar rock derived from other varieties of it and the alteration of the modified quartz diorites. I have also found a case where what appeared to have been a comminuted mass of felspar and decomposed hornblende which may have been derived from diorite was separating into interrupted layers of pure felspar with others of schist which by further alteration would form a rock like gneiss.

The clay slates associated with the greywackés are, in some parts of the region, black or nearly so. On the Onaping river these may be traced into a black breccia which is clearly of volcanic origin, largely developed near Onaping station on the Canadian Pacific Railway, which would show that the black color in Huronian slates is not necessarily organic and that any theory based on the supposition that it is so may be erroneous.

The dolomites of this region are evidently in most cases of a concretionary or segregated nature, and have probably been derived from the decomposition of the hornblende or the augite of the rocks with which they are associated. Small unstratified masses of this rock are not uncommon in the diorites, syenites and greywackés where they have been formed *in situ*, while the layers and stratified deposits may have been precipitated from waters which carried the carbonates of lime and magnesia to short distances from the hornblendic or augitic-bearing rocks undergoing decomposition.

During the process of converting the greywacké into syenite, the diffused iron which it contained has been gathered either into great numbers of strings or small veins of magnetite or into a few larger ones of the same ore which, however, I have never seen wide enough to be worked. Veins of this kind are interesting as showing the probability of the formation of more extensive larger ones of iron oxides without the existence of organic life as a means for the concentration of the metal.

The above notes touch on nearly all the stratified and some of the unstratified rocks of this Huronian region and it is hoped that they may have suggested some points of interest for discussion.

ON CERTAIN REMARKABLE NEW FOSSIL PLANTS FROM THE ERIAN AND CARBONIFEROUS, AND ON THE CHARACTERS AND AFFINITIES OF PALÆOZOIC GYMNOSPERMS. By Sir WILLIAM DAWSON, Principal McGill College, Montreal, Canada.

[ABSTRACT.]

THE paper describes a new genus and species, *Dictyocordaites Lacoi*, discovered by Mr. R. D. Lacoe in the Catskill formation in Pennsylvania, also specimens of the fructification of *Dolerophyllum*, collected by Mr. Lacoe, and specimens of *Tylodendron* collected by Mr. Francis Bain in the Permo-carboniferous of Prince Edward Island. The affinities of these plants are then discussed, and their relations to other gymnospermous plants of the Palæozoic, in connection with a review of the present state of knowledge of Palæozoic gymnosperms.

THE REALITY OF A LEVEL OF NO STRAIN IN THE CRUST OF THE EARTH.

By Prof. E. W. CLAYPOLE, Akron, Ohio.

[ABSTRACT.]

THIS paper contains a brief review of some recent discussions on this subject and presents in an untechnical manner the principal proposition and the reason by which it is supported. According to the mathematicians the cooling shell of the earth is contained for purposes of calculation between the surface and the depth of four hundred miles. Within these limits therefore nearly all the effects of cooling must be exhibited. The two chief factors in the problem are the cooling and contraction of each successive shell of small thickness and the subsidence of every layer in consequence of the shrinkage of those below it.

The shrinkage by cooling of each layer being greater toward the bottom of the series than the loss of room incurred by descent to a lower level, the curve representing the former lies at a greater distance from the axis than that representing the latter. But the former reaches a maximum and begins to diminish toward the surface while the latter constantly increases upward. Consequently, there must be a point where these loci intersect and this point of intersection will indicate the position of the shell of no strain. The paper concludes with some notes on the position of this shell in early times and with some geological reasons that set limits to its depth at the present day.

OBSERVATIONS ON SOME OF THE TRAP RIDGES OF THE EAST-HAVEN-BRANFORD, CONN., REGION.

By E. O. HOVEY, Ph.D., Waterbury, Conn.

[ABSTRACT.]

THIS paper takes up a question that has been discussed by geologists with more or less vigor for the last seventy years. The region explored in connection with its preparation is a small one lying east and southeast of the city of New Haven, Conn., but it includes the Pond Rock region, which has been taken by Prof. W. M. Davis of Harvard (one of the latest and most voluminous writers on the subject) to be typical of the whole Connecticut Valley Triassic. After a brief description of the topography of the region, its long sandstone ridges and striking outcrops of trap, the writer discusses the character and age of the trap ridges. These are arranged in about six ranges extending about N.N.E. and S.S.W. one of which, Pond Rock, is perfectly continuous, but the others are broken up into numerous parts. The most western of these ranges is made up of undoubted dikes cutting obliquely across the strata of sandstone, and some members of the next two ranges east of this also show themselves as dikes. Professor Davis says that Pond Rock is an overflow sheet on account of "its small metamorphic effect at the base, its decided amygdaloidal texture on its back or upper surface, its irregular and brecciated structure, and its alteration

and hydration." The writer's observations in this region and elsewhere lead him to conclude that no ratio between the thickness of a trap dike or sheet and the amount of induration of adjoining sandstone can be laid down, and that the extent of the induration of the underlying sandstone of Pond Rock is not a proof of the extrusive origin of the trap; that the amygdaloidal texture is not confined to the upper surface of an overflow but may occur in the interior of a dike or throughout the mass of an intrusive sheet; that the irregular and brecciated structure was produced by rapid cooling and subsequent alteration in places where the trap sheet was originally thinnest, and that the alteration and hydration are not as great as they are in a large undoubted dike in the western part of the region. The sandstones and shales overlying the trap of Pond Rock give positive evidence by their dipping at a much higher angle than the underlying sandstone that the trap sheet is intrusive and not extrusive in origin. The ranges east of Pond Rock also are intrusive. As to the age of the trap: Pond Rock and the range next west of it are probably older than the tilting of the sandstone, or of Triassic age, while the trap of the other ranges was probably intruded when the upheaval had been nearly or quite completed.

The communication was accompanied by a map on a large scale showing the position and shape of every exposure of trap (about 270 in all) in the region. The roads and watercourses were laid down partly from surveys by the U. S. Government and partly from surveys of the writer, but all by the trap ridges were put in from the writer's own observations.

THE DEVONIAN SYSTEM OF NORTH AND SOUTH DEVONSHIRE. By Prof. H. S. WILLIAMS, Ithaca, N. Y.

[ABSTRACT.]

AN account is given of an examination, recently made by the author, of the original Devonian sections and their fossils.

As a result of a comparison with the Devonian of the Appalachian basin and New York the conclusion is drawn "that (*a*) the fossils are very closely allied to the species in the New York Devonian, although in the great majority of cases passing under different names, and, (*b*) that the rocks in their appearance, composition and order are as different as two distinct systems well can be."

The Devon limestone of South Devonshire furnished the fossils upon which Lonsdale, in 1839, based his conclusion that the fauna was intermediate between the fossils of Murchison's Silurian system and those of the carboniferous limestones, which led to the establishment of a "Devonian system."

When other European localities had furnished more perfect sections this

fauna was recognized as a middle Devonian fauna; that of Pilton, Barnstaple, Braunton, etc., was a higher fauna and was called Upper Devonian.

But neither the order of sequence of the rocks nor the separation of the fossils into well defined faunas can be satisfactorily determined from study of these Devonian rocks alone. Although they have furnished geological nomenclature with a name for the system they are far from being typical of the Devonian system.

Comparison of the faunas of the European Devonian faunas with those of the Appalachian basin leads to the hypothesis that the marine faunas of the two areas had different histories. There is a continuity in the succession from the lowest to the highest faunas of the system in Europe which we do not find in the American series.

It is evident that the American Hamilton and lower faunas are more distinct from the corresponding middle Devonian faunas of Europe than are the "Cuboides" and upper Devonian faunas of the two areas from each other.

To account for these facts it is conjectured that a barrier separated the two faunas during the lower and middle stages of the Devonian, and that at the "Cuboides" stage an incursion of European species took place into the Appalachian basin, but this incursion was not complete and was stopped by the elevation which terminated the Chemung marine fauna in the New York region.

Also it is conjectured that the evidence points to an advance northward of the early carboniferous faunas of the central basin of North America, to take the place of the Hamilton and Chemung faunas which in large measure ceased.

THE GEOLOGICAL POSITION OF THE OGISHKE CONGLOMERATE. By Prof. ALEXANDER WINCHELL, Ann Arbor, Michigan.

[ABSTRACT.]

THE Ogishke Conglomerate is found in the basin of Ogishke Muncie or Kingfisher Lake, in the extreme northeastern part of Minnesota. It consists of a mass of vertical slates, mostly dark, argillitic, hard and thick-bedded, with cleavage coincident with the bedding, through which are distributed rounded pebbles of gneissic, quartzose and doleritic rocks, arranged in definite courses, and so firmly embedded that rupture of the formation passes with equal readiness through the pebbles and the matrix. These conglomeritic beds stand in the strike of the black silicious argillites of Knife Lake on the west, and of the argillites and sericitic schists of Vermilion Lake. The structural indications are that the conglomerate belongs to the iron-bearing formation of Vermilion Lake. But, the opinion has been advanced that it represents the Animike formation. The Animike is now well known from Thunder Bay of Lake Superior to Gunflint Lake,

which is only twelve miles east of Ogishke Muncie. In a more southerly region the Animike extends a hundred miles further west. There are some plausible reasons for thinking the Ogishke belongs to the Animike. The object of the communication was to show that such an identification is incorrect.

The speaker's observations were cited, which show the Ogishke to be a part of the Vermilion iron formation. Citations were also read from the Canadian Reports, showing the character of the Animike formation or "lower group of the Upper Copper-bearing series" of Logan, and showing that nothing like the Ogishke is included in it. Citations were also read from the Reports of Logan, Macfarlane and Bell, showing that the so-called Huronian of Thunder Bay embraces a conglomerate *exactly* resembling the Ogishke. This lies near the bottom of the so-called Huronian, and unconformably underlies the Animike. The Vermilion iron-bearing series also unconformably underlies the Animike. The inference is that the Ogishke belongs to the Vermilion iron-bearing group, as it appears to. A further inference is that since the Animike agrees in character with the original Huronian, north of Lake Huron, the so-called Huronian of Lake Superior is older than the true Huronian, and the Vermilion iron-bearing rocks so generally referred to the Huronian have been misplaced.

ON A POSSIBLE CHEMICAL ORIGIN OF THE IRON ORES OF THE KEEWATIN IN MINNESOTA. By Prof. N. H. WINCHELL and H. V. WINCHELL, Minneapolis, Minn.

THE proper understanding of the limits of this discussion requires a brief statement of some recent stratigraphic determinations. It is evident that the papers of the late Prof. R. D. Irving[1] and of Prof. C. R. Van Hise,[2] while in the main considering the problem from the point of view of the "Huronian," have also embraced within the scope of the phenomena cited, a group of strata much older, which lie everywhere,[3] unconformably under the Huronian and which present a series of facts which are distinct from those appertaining to the Huronian as found in the Penokee-Gogebic and Mesabi regions. The confounding of two formations, and the placing in one category the chemical and structural phenomena that are separated into two series by a great time-interval, and by structural unconformity, have so complicated the problem that hitherto no theory has been found capable of covering all the facts. The existence of this widespread unconformity has been shown in recent reports on the geology of the northwest by A. C. Lawson, A. Winchell and the writers; and latterly it was

[1] *Am. Jour. Sci.* (III), XXXII, 255. [2] *Am. Jour. Sci* (III), XXXVII, 32.
[3] Compare the 17th An. Rep. of Minn. Geol. Surv. pp. 42–45.

also recognized by Irving.[1] By Professor Irving, however, there had not been, prior to his death, so far as known, any reconstruction or limitation of his general theory of the origin of the iron ores.

It is the purpose of this paper, while not calling in question the explanation by Irving of the origin of the ores of the Huronian, to show specifically, a possible origin for those of the Keewatin as they are found in the Vermilion range in northeastern Minnesota.

That there is reason to account for the Vermilion ore on a different hypothesis from that which may be sufficient for the Huronian ore, is evident from a consideration of the following differences in the formations. The Huronian strata are of fragmental origin, accumulated by the slow process of sedimentation, and are siliceous; being banded by lines of deposition that fade from one sort into another by such insensible transitions as can be produced by successive variations in the forces of an ordinary sedimentary process. This structure not only pervades the rock that embraces the ore, but passes into the ore itself. The formation as a whole, and certainly the beds that embrace the ore, are made up of secondary grains derived from some other formation. In other words it is non-crystalline. (Irving, 3rd An. Rep. U. S. Geol. Sur. pp. 157–165. 16th An. Rep. Minn. Sur. p. 39.)

On the other hand, the strata that carry the iron ore deposits of the Keewatin, when not rotted *in situ*, are crystalline or sub-crystalline, and do not vary in composition like a sedimentary rock. They do not show, except very rarely, any transitions between the ore and the enclosing rock, and when they do show such a mingling the alternations are between two kinds of material, and without the intermixture of clayey substances. The two materials are the *ore itself* and the *country rock*. But the country rock is uniformly constituted of diabasic schist which shows either its direct origin from eruptive, basic rock, or its quick distribution and deposition in waters heated by volcanic disturbances; and but rarely has so much intermingled silica of secondary, sedimentary derivation, as to raise the per cent of silica above the limit of Von Cotta for a basic rock. At points remote from the ore lodes the proportion of silica increases, and it is besides not wholly of the characteristic chalcedonic sort that prevails in the ore and in proximity to it. But, instead, some part of the silica found in strata distant from the ore lodes is in the form of rounded grains of vitreous quartz such as is chemically deposited in ordinary quartz veins. Besides silica, an aluminous element also displays itself in the formation at points removed from the mines.

Another noticeable difference between the Huronian and the Keewatin ores consists in the gradual changes that are seen to occur in the Keewatin ore as the country rock becomes more and more crystalline, massive and diabasic. In passing eastward from Tower the hematite is seen to give place gradually to magnetite, *pari passu*, as the green schists assume the character of unmodified diabase; and in the vicinity of Snowbank lake

[1] *Seventh An. Rep. U. S. Geol. Survey.*

the iron ores are magnetitic jasperoid lodes embraced in such massive diabase,[1] conforming in general with the strike of the rocks of the region, and still showing all their necessary relations to the Keewatin formation. These characters are found, not in the lower, often lake-filled, valleys, but on the hills at elevations of several hundred feet. No such phenomena have ever been reported from the Huronian. The eruptive, diabasic rock of the Huronian mines either underlies the iron-bearing strata unconformably, as described by Dr. Rominger, or is in the form of transverse dikes that cross both the country rock and the ore beds, as recently described by Van Hise.[2]

Not only in respect to age and geological relations do these ores differ, but chemically they are quite different. The points of dissimilarity are prominently revealed in making a comparison of their impurities. The Keewatin ores contain silica as their chief impurity, the amount of phosphorus, determining the Bessemer or non-Bessemer grade, not being noticeably different from the Huronian ore. But in respect to other impurities the Huronian ores contain about 300 per cent more manganese; about 400 per cent more sulphur; about 83 per cent more alumina; about 25 per cent less of magnesia; about 400 per cent more lime and about 400 per cent more water.[3] The Huronian ore is generally soft, and sometimes is a limonite passing to siderite. The Keewatin ore is hard, never limonitic, and has not been known to contain any carbonate of iron.

The objections to the eruptive hypothesis of Foster and Whitney, lately revived by Dr. Wadsworth, have been stated in the fifteenth report of the Minnesota survey, and it is not necessary to dwell upon them here. The extreme length to which Dr. Wadsworth is carried by his predilection for eruptive agencies is seen in his arguing[4] that the quartzyte at Republic mountain is eruptive. One of the chief obstacles to this theory is the novelty of the proposition to enclose fused silica in the same mass with crystalline hematite and require them to cool without chemical union, the former retaining an amorphous state and the latter not losing its crystalline structure. Another obstacle is the plainly sedimentary banding that the ore presents, *i. e.*, the jaspilyte, which is unlike any structure known to result from the cooling of molten rock, and which unmistakably reveals the action of water in the formation of long parallel bands or strata.

The difficulties of applying the theory of Irving, *i. e.*, the metasomatic substitution of oxides of iron for some preëxisting carbonate, appear when we search for the remains of the supposed older carbonate, and when we find that the country rock does not afford good reason to have expected the deposition of any carbonate: and also when we search for the remaining ingredients which the assumed metasomatic process may have

[1] *Am. Geol. Jan.* 1889, p. 19; *17th Rep. Minn. Sur.* p. 122.

[2] *Am. Jour. Sci.* (III), XXXVII, 32.

[3] These results are based on average analyses for 1888, published by Pickands, Mather and Co., derived from several thousand assays.

[4] Notes on the Geology of the Iron and Copper districts, *Bul. Mus. Comp. Zool.* Geol. Series, Vol. 1, p. 54.

left in the ore. In short, the whole mass of geological and mineralogical environment, as seen in the Huronian rocks, is at variance with that seen in the Keewatin, and precludes the hypothesis that ordinary chemical substitution will account for the chalcedonic silica and the hematite of the jaspilyte lodes.

But that chemical processes played a prominent, if not a principal, part in the formation or the jaspilyte, and in the metamorphism of the strata of all the Archæan, there is no disposition to call in question.[1] It is here appealed to as the prime agent in giving origin to the chalcedonic silica and the iron ore of the jaspilyte.

In order that the physical circumstances which obtained during the age of the crystalline and sub-crystalline schists, *i. e.*, during the age of the Vermilion and of the Keewatin, may be fairly apprehended, and brought to bear upon this inquiry, it will be necessary to mention some inferences that have recently been wrought out by the study of the Archæan.[2]

It has been stated repeatedly, by G. M. Dawson,[3] by A. C. Lawson[4] and by the writers,[5] that the rocks of the Keewatin consist very largely of volcanic ejectamenta. These ejectamenta were received in oceanic waters. The volcanoes themselves were mainly submarine, and the products of any intervening stage of sedimentary quiet were buried under the lavas of the next quickly succeeding stage of eruption. Whether this eruptive stage was world-wide, in its production of this kind of basic schist, as seems very likely, it is not necessary here to inquire; but that it was one of great duration, and prevailed in all of northeastern Minnesota wherever this rock horizon has been examined, and extended into Manitoba, there is no longer any room to doubt. It is therefore necessary to inquire how such products as chalcedonic silica and hematite could have been formed in a sea that was at times seething and steaming with volcanic craters and earth-fissures, from which escaped molten material from below the thin crust. That this chalcedonic silica, involved closely with interbanded hematite, and grading into it by insensible variations inthe amount of iron present, was received in water and distributed by water, is indicated not only by the stratiform arrangement, but also by the presence, occasionally, but very rarely, of rounded grains of other silica, not chalcedonic, some of them being a quarter of an inch in diameter, embraced in the general mass of the jaspilyte and sometimes forming more or less distinct belts or pebbly patches in the jaspilyte, approximately parallel with the general strike. This fact effectually vetoes the eruptive theory, and demonstrates that there was no exception in favor of that theory, so as to produce a structure characteristic of sedimentation, through the agency of molten acid lava flows.

[1] A. Winchell, *Fifteenth Report, Minnesota Survey*, p. 196.

[2] *Seventeenth Annual Report*, Minnesota Survey, pp. 37–40.

[3] *Geology and Resources of the 49th parallel*, 1875, p. 52.

[4] *Geology of the Lake of the Woods*, Can. Survey Rep. 1885, C, pp. 40–54.

[5] *Fifteenth report, Minnesota Survey*, 1886, p. 221; *16th Report*, p. 108. *17th Report*, p. 37; *Am. Geologist*, Jan. 1889, Vol. III, p. 22. Compare, also, Foster and Whitney, on the "Azoic," *Report on the Lake Superior land district*, 1851, Part II, p. 67.

When the character of some of the narrow bands of pure white and translucent silica is duly considered, and it is compared with the known product of chemical precipitation from silicious waters, the idea of *chemical precipitation* is forcibly presented as the possible origin for the chalcedonic silica of the jaspilyte. There is no way known in nature for the formation of chalcedonic silica except by chemical deposition. The different bands of the jaspilyte, varying in color from white to red, brown and sometimes nearly black, are all formed by the varying proportions of hematite and silica. Ordinary sedimentary action could not select from the products of erosion simply two substances and unite them in characteristic strata, when the ocean's waters must have been charged with suspended matter of many different kinds. Some selective, discriminating force was at work which was able to abstract silica, or silica and iron oxide, from the water and reject all the rest.

In the light of what has already been said regarding the nature of the schists enclosing the ore masses, it is plain that the waters of the Keewatin ocean were constantly agitated by volcanic eruptions. It is also plain that they must have been hot, and in some places, or after irregular intervals of time, must have been rapidly evaporated and at other times suddenly cooled. The earth's crust was thin and easily rent, and the contact of water and molten rock was frequent. The water became alkaline by solution from the lavas of the magnesia, potash and soda and other alkaline elements. In this condition it would also become surcharged with soluble silica and iron, obtaining the latter from the augitic minerals of the basic lavas, and possibly from masses of erupted metallic iron. Indeed, the ocean was a hot compound decoction of all the minerals that could be dissolved from the eruptive diabases; and of those minerals there was no exception.

Under such circumstances it requires no extensive research nor chemical foreknowledge, to predict what would be the result whenever the equilibrium of super-heated and super-saturated oceanic water was disturbed. Something would be precipitated. Would it be silica and ferric oxide?

On this point Hunt says[1]: "The atmosphere, charged with acid gases which surrounded the primitive rock, must have been of immense density. Under the pressure of such a high barometric column, condensation would take place at a temperature much above the present boiling point of water; and the depressed portions of the half-cooled crust would be flooded with a highly-heated solution of hydrochloric and sulphuric acids, whose action in decomposing the silicates is easily intelligible to the chemist. The formation of chlorides and sulphates of the various bases and *the separation of silica* would go on until the affinities of the acids were satisfied, *and there would be a separation of silica, taking the form of quartz*, and the production of a sea-water holding in solution, besides the chlorides and sulphates of sodium, calcium and magnesium, salts of aluminum and other metallic bases" . . . . "Quartz has not only never been met with as a

[1] T. Sterry Hunt. *The Chemistry of the Primeval Earth.* *Am. Jour. Sci.* Jan, 1858. *Smithsonian Report*, 1869, p. 189, *Chemical and Geological Essays*, 1878, p. 40.

result of igneous fusion, but it is clearly shown by the experiments of Rose, that a heat even much less than that required for the fusion of quartz destroys it, changing it into a new substance, which differs both in chemical and physical properties from quartz." . . . . "The first precipitates from the waters of the primeval sea must have contained oxidized compounds of most of the heavy metals." "The large amounts of silica contained in solution in the waters of some thermal springs and of many rivers, are separated when these waters are exposed to spontaneous evaporation, partly as silicates of lime and magnesia, and partly in the forms of crystallized quartz, hornstone and opal. In many different formations beds are met with composed entirely of crystallized grains of quartz which have apparently been deposited from solution. In other sediments this element abounds in the form of grains of chalcedony or as amorphous soluble silica. The beds and masses of chert, flint, hornstone, buhrstone, and many jaspers, have all apparently been deposited from aqueous solutions."[1]

Prof. A. Winchell thus refers to this primeval ocean and the precipitation of silica:[2] "The liberated silica would separate and would be chemically precipitated during the subsequent cooling of the waters, and would thus give rise to the enormous beds of quartz which we actually find among the very oldest strata."

Concerning the similar production of beds of iron oxide, Hunt states:[3] "Those chemical compounds which were most stable at the elevated temperature then prevailing would be first formed. Thus, for example, while compounds of oxygen with mercury, or even with hydrogen, could not exist, oxides of silicon, aluminium, calcium, magnesium and iron might be formed. . . . . . All the elements, with the exception of the noble metals, nitrogen, chlorine, the related haloids, and the hydrogen combined with these, would be united with oxygen. The volatility of gold, silver and platinum would keep them still in a gaseous condition at temperatures where silicon, and with it the baser metals, were precipitated in the form of oxides."

These quotations might be multiplied. The formation of siliceous and irony deposits from oceanic waters is referred to by Gustav Bischoff,[4] J. W. Dawson,[5] and by nearly all geologists who have written of the chemical reactions of the primeval ocean. Much speculative literature has been published relating to the early co-relations of the consolidating crust, the heated interior and the enveloping atmosphere of the earth. But very often no actual account has been taken of these theories in the practical work of the field geologist. The drama of sedimentation, and the erosion of shores, and the transportation of material by currents, forming the later strata of the super-crust, have been duly investigated, but this theoretical age of seething, alkaline, oceanic water, the actual causes that produced

[1] Hunt, *Geology of Canada*, 1863, p. 574.
[2] A. Winchell, *Sketches of Creation*, 1870, p. 59.
[3] T. Sterry Hunt, *Smithsonian Report*, 1869, pp. 186, 189.
[4] *Chemical and Physical Geology* (Cavendish Society) Vol. I, pp. 143, 146.
[5] *Quart. Jour. Geol. Soc.*, Vol. V, p. 25.

it, the resultant rock that attests its existence and the position it holds in the strata of the Archæan, have not had their analogous demonstration and adequate description in geological literature. The writers believe that the Keewatin age was characterized by these forces and events and that the green schists, whether sericitic or chloritic or diabasic, that fundamentally constitute the bulk of its rocks, and the jaspilyte lodes, exemplify the chemical precipitations and the mechanical depositions that the theories require. So long as the term "Huronian" was made to cover the actual Huronian strata, as well as all lower beds down to the Laurentian base, it was difficult, if not impossible, to invoke world-wide forces in one portion of the stratification that nullified those that were demanded to produce the rocks of the other. By the separation of the Keewatin from the Huronian a different set of conditions may be relied on, but none other than those that are needed to produce the rocks which are found to compose it.

It is not the purpose of this paper to explain any of the physical conditions of the jaspilyte, nor of the strata that compose the bulk of the Keewatin, such as brecciation, folding and involute contortion, compression, fracturing and transportation of strata once formed, the upheaval and prevailing verticality of the beds. These, in the main, must have been produced subsequent to the chemical precipitation here appealed to to explain their origination, but to a certain extent seem to have been contemporary with the precipitation of the beds themselves. But it is our sole purpose to account for the existence of the jaspilyte by some hypothesis consistent with known chemical laws, and in accordance with such surroundings and physical forces as the nature of the Keewatin rocks shows to have obtained at the time of its formation. This hypothesis not only is consistent with these laws and conditions, but it explains some of the features of the jaspilyte which no other theory, so far proposed, will explain. Some of these peculiar features may be mentioned, namely: (1) It accounts for the minutely fine structure of the silica, and for the uniformity of its granular texture upon disintegration; (2) It accounts for the prevalence of this structure at all depths in the earth, wherever the jaspilyte is found to extend; (3) It accounts for the agate-like banding and the minuter lamination that characterize the jaspilyte; (4) It furnishes an explanation for the purity of the white chalcedonic ribbons, which consist of silica only; (5) It explains the re-cementation of some of the thin, brecciated layers by material of the same kind as the layer itself; (6) It explains the occasional intrusion of rounded grains of non-chalcedonic quartz into the mass of chemically precipitated quartz; (7) It explains, lastly, the occasional mingling of chalcedonic silica with the finer elements of the basic schists, forming regular sedimentary alternations.

Summary. All attempts hitherto made to account for the existence of the iron ores of the Northwest, particularly those of Professors Irving and Van Hise, have confounded the phenomena of two unconformable formations that manifest constantly distinct contrasts of stratigraphy and lithology.

The theory of Foster and Whitney, that these ores are of eruptive ori-

gin, is opposed by chemical laws and by structural peculiarities that cannot be reconciled with it.

The ores of the Keewatin are markedly different from those of the Huronian in their chemical impurities.

The theory of metasomatic substitution of iron oxide for some carbonate, while applicable to the ores of the Huronian on the south side of lake Superior cannot be made to account for the ores of the Keewatin, because, (1) There is no evidence of the existence, at any time, of the necessary earlier carbonate; and (2) The nature of the country rock embracing the Keewatin ore is such as to imply that no carbonates, in the amounts required by the theory, could have been deposited at the time the rocks were being formed.

There is therefore necessity for some other explanation than that applicable to the Huronian ores.

Chemical precipitation in hot oceanic waters, united with simultaneous sedimentary distribution might produce the Keewatin ores in a manner consistent not only with the physical conditions that prevailed at the time of their formation, and with the structural peculiarities which they exhibit, but also in accordance with the known reactions of heated alkaline waters, and with the chemical character which the ores are known to possess.

THE EAGLE FLATS FORMATION AND THE BASINS OF THE TRANS-PECOS, OR MOUNTAINOUS REGION OF TEXAS. By ROBERT T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THE portion of Texas west of the Pecos river is described as a series of complicated mountain disturbances, accompanied by much faulting and eruptive material. The largest portion of the area, however, consists of extensive flats lying between the mountains, which are shown to be almost recent lake beds, drained of their waters, except in rare instances where salt lakes still occupy limited portions of these basins. The quaternary or later sediments of these former lakes are described as the Eagle Flats formation.

THE IGNEOUS ROCKS OF CENTRAL TEXAS. By R. T. HILL and E. T. DUMBLE, University of Texas, Austin, Texas.

[ABSTRACT.]

PILOT Knob, Travis County, Texas, is described as the type of an intermittent line of basaltic rocks often of columnar structure protruding through the cretaceous limestones of Central Southern Texas from east of

Austin to the Rio Grande. The age is shown to be Post Eocene, and the name Shumard system is proposed for this hitherto unclassified eruptive topographic feature.

These eruptives (?) extend a little north of east from the Rio Grande in the vicinity of Fort Clark, to Austin, Texas. The isolated eruptive areas of Rockwall county, Texas, and Pike county, Arkansas, are in line with this system, and probably all are along a line of weakness in the earth's crust which has apparently existed in this region. The time of the eruption is shown to have been Post Eocene.

THE GEOLOGY OF THE STAKED PLAINS OF TEXAS, WITH A DESCRIPTION OF THE STAKED PLAINS FORMATION. By R. T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THE Staked Plains are shown to be an extensive mesa, which was an interior base level in late Tertiary or early Quaternary time. Its surface is covered by a fresh-water lacustral sediment, consisting of loam and gravel for which the name of the Staked Plains formation is proposed.

THE GEOLOGY OF THE VALLEY OF THE UPPER CANADIAN FROM TASCOSA, TEXAS, TO TUCUMCARRI MOUNTAIN, NEW MEXICO, WITH NOTES ON THE AGE OF THE SAME. By R. T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THIS valley is shown to have been a more ancient piece erosion than that accomplished by the present river which flows through it. It is from forty to sixty miles wide and eight hundred feet beneath the ancient base level of the staked Plains, and filled with a detrital deposit for which the local name of the Terra Blanca formation is proposed.

A CLASSIFICATION OF THE TOPOGRAPHIC FEATURES OF TEXAS WITH REMARKS UPON THE AREAL DISTRIBUTION OF THE GEOLOGIC FORMATIONS, WITH MAP. By R. T. HILL, University of Texas, Austin, Texas.

[ABSTRACT.]

THE Texas region is described and its topographic features defined as a series of ancient base levels, striking approximately north and south, and limited by two orographic systems, the more ancient and northern

one being the Onachita system of Branner, in Arkansas and Indian Territory, and the southern, the mountains of northern Mexico and the Trans-Pecos region of Texas. Certain conspicuous valleys of erosion are explained, and the progress of denudation described. The relation of this topographic classification to the cultural possibilities of the region, and to the distribution of the floras and faunas is also shown.

A NOTICE OF SOME ZIRCON ROCKS IN THE ARCHÆAN HIGHLANDS OF NEW JERSEY. By FRANK L. NASON and WALTER F. FERRIER, Assistant Geolgists, Survey of New Jersey, New Brunswick, N. J.

[ABSTRACT.]

DURING the progress of the New Jersey Geological Survey in the autumn of 1888 and the summer of 1889, several localities of a peculiar zircon rock have been observed.

In the report of the Geological Survey of 1868, mention is made of a zircon-bearing gneiss at Trenton.[1] Zircons were reported also from Swede's mine,[2] Rockaway township; and also at Wawayanda mine,[3] Vernon township.

If other localities were known at this time, no mention was made of the fact.[4] With the exception of the Trenton gneisses, the mineral was found in the ores of the mines. Zircons have since been found in many of the iron mines, but in rather minute crystals and in sparing quantities. The localities in question, however, present marked exceptions to the above-mentioned occurrences. The mineral is a very prominent constituent of the rock, amounting, in some masses, to nearly twenty per cent of the specimen. The average would probably reach five per cent of the mass. The other minerals composing the rock are magnetite, titanic iron ore, quartz, feldspar (orthoclase and plagioclase) and hornblende. Accessory minerals are sphene, rutile, biotite and probably pyroxene.

In structure, foliation and bedding are wholly absent. The quartz is often porphyritic, sometimes having the peculiar appearance of quartz in graphic granite.

In the field, at the three localities observed, the rock, as a whole, has the appearance of a huge eruptive boss or a volcanic neck. Fragments of other rocks appear to be enclosed in the mass. Certainly, there do occur foreign rocks, but whether these are fragments included in an eruptive mass or only portions unchanged by a reworking of the rock mass, it is not at present possible to determine. This much is certain, however, that the position and appearance of the rocks in the immediate neighborhood lend abundant support to the eruptive hypothesis.

[1] Ann. Rep. State Geol. Survey, 1868, Dr. Geo. H. Cook, State Geologist, p. 323.

[2] Ann. Rep. State Geol. Survey, 1868, Dr. Geo. H. Cook, State Geologist, p. 323.

[3] Ann. Rep. State Geol. Survey, 1868.

[4] Mention is made in the former reports of Rogers.

The abundance of magnetite in the rock is so great as to give considerable dip to the miner's needle. This led to the search for workable deposits of iron ore, and the numerous shafts thus sunk afford opportunity to study the rock to some depth below the surface. The idea of working the localities for iron ore is now abandoned, but it is a fair question as to whether the zircons, occurring as abundantly as they do, may not be of economic importance, provided that a cheap method of separation can be devised.

The survey made experiments with this end in view. A sluice box, twelve feet in length, was employed. No zircon was observed in the tailings, but was found to be caught with the magnetite and titanic iron on the first three riffle bars. This mixed material, subjected to the action of a powerful electro-magnet, frees the zircon from the ore and leaves it pure. The magnet must be a powerful one on account of the presence of titanic iron.

The process of preparing the rock for washing is facilitated by the ready separation of the zircon crystals from their matrix. A crystal exposed in a rock needs only a slight tap to detach it.

The most interesting feature of the rock is the zircon crystals which are well developed and of a beautiful, reddish-brown color. Some of the smaller ones are almost transparent, resembling the hyacinth variety of the mineral. In a hurried examination of the crystals, the principal planes observed were ∞P, P $3P$, $3P3$ and $\infty P \infty$, but many undoubtedly occur, and the locality might afford interesting material for crystallographic study, as the planes in the smaller crystals are well formed and brilliant and so admirably adapted to measurement. Twins occur, the twinning plane being $P\infty$ as in the crystals from Renfrew, Ontario. A large proportion of the crystals exhibit the ditetragonal pyramid.

The crystals vary in size from microscopic needles to about 5 mm. in diameter and 25 mm. in length. The average are about 2 mm. in diameter and 5 mm. in length. They nearly all exhibit a curious lateral compression, are often bent and present the peculiar pitted or corroded appearance so often seen in apatite. Surface specimens in many cases have a most brilliant iridescent tarnish.

The convexity of the pyramidal faces, so characteristic of the species, was frequently observed in the larger crystals.

This interesting rock is now under investigation by the survey and further particulars will appear in the next annual report.

NOTE ON THE MAPPING OF THE ARCHÆAN NORTHWEST OF LAKE SUPERIOR. By Dr. ANDREW C. LAWSON, Ottawa, Ont.

[ABSTRACT.]

THE writer exhibited a general geological map of the Archæan country between Red River Valley and Lake Superior, showing the results of recent investigations which he has been conducting for the Geological Sur-

vey of Canada. The proof of a new geologically colored map of the Rainy Lake region, shortly to be issued by the survey, was also exhibited to illustrate the details of a portion of the general map. The relative distribution of the Upper and Lower Archæan, as displayed on the map, was shown to be peculiarly interesting and instructive. The Lower Archæan or Laurentian, consisting of various, more or less foliated granites and syenites, which have hitherto been regarded as the oldest rocks, was shown to occupy large, isolated boss-like areas which appear to be irruptive or intrusive through the schists. The general mapping of this portion of the country, where denudation has left the Upper and Lower Archæan in nearly equal proportions, strongly supports the view that the Laurentian rocks are of later age than the schists of the Upper Archæan and were irrupted through them.

The importance of careful mapping as an aid to the solving of the profound problems of Archæan geology was dwelt on, and other evidence which the writer has adduced elsewhere in support of the irruptive nature of the Laurentian was referred to.

PETROGRAPHICAL DIFFERENTIATION OF CERTAIN DYKES OF THE RAINY LAKE REGION. By DR. A. C. LAWSON and F. T. SHUTT, M. A., F. C. I., Ottawa, Ont.

[ABSTRACT.]

ONE of the writers has described in a former paper certain diabase dykes of the Rainy Lake region. The present paper is the result of a more critical investigation of the same dykes, with others since discovered, having special reference to the petrographical differentiation of the dyke rock in passing from the contact walls to the centre of the dyke. The fact that dykes are very commonly fine grained at their margins and coarse grained in their middle parts is familiar to all geologists. On examination of the dykes in question, it became apparent that this variation in the physical appearance of the dykes is not simply one of *texture* or degree of coarseness of the constituent minerals, but that it is rather the incidental concomitant of important *structural*, *mineralogical* and *chemical* variations which appear very constantly in the same way in different dykes. These variations are chiefly as follows: *Structural* — the passage from the structure of a very fine textured diabase-porphyrite at the contact walls through the characteristic ophitic structure of diabase at a few feet from the contact to the granular structure of gabbro in the middle part of the dyke. (Illustrative drawings were submitted.) *Mineralogical* — the passage from a quartzless rock at the contact to a quartzose one towards the middle of the dyke. *Chemical* — the passage from a more basic rock near the contact to a more acid towards the middle. The results of complete or partial analyses by Mr. Shutt of series of specimens taken across a number of dykes were given in tabular form.

The principal object of the paper is to adduce specific evidence that from a rock mass which is a geological unit of very limited extent, there may be taken specimens which under current methods of classification would receive different names and be relegated to different classes. The fact that a series of specimens, in any given locality, differ from one another texturally, structurally, mineralogically and chemically, is no proof that they are not geologically the same rock crystallized from the same magma. The regular textural and structural differentiation of the dykes from wall to middle is inferred to have been caused by the different rate of cooling under constant pressure. The chemical differentiation is probably due to a selective crystallization of the more basic minerals in the earlier stages of solidification accompanied by the transference of acid residues from the sides to the middle by the agency of included water.

THE LAKE RIDGES OF OHIO AND THEIR PROBABLE RELATIONS TO THE LINES OF GLACIAL DRAINAGE INTO THE VALLEY OF THE SUSQUEHANNA. By Prof. G. FREDERICK WRIGHT, Oberlin, O.

[ABSTRACT.]

THE map of the glaciated area of the eastern part of the United States shows that the sides of the angle formed by the ice-front at Salamanca, N. Y., are closely parallel with the shores of Lake Erie, to the northwest and to the course of the valley of the north branch of the Susquehanna and its extension up the Chemung and Canisteo rivers, on the northeast. In consequence of this parallelism it is evident that the cols from the Erie-Ontario basin into the Susquehanna valley must have been uncovered simultaneously with the retreat of the ice from the south shore of Lake Erie. It is probable, therefore, that the lowest of those cols, that south of Seneca Lake, which is only a trifle higher than the upper ridge south of Lake Erie, controlled the level of the glacial lake, Erie-Ontario, for a considerable period of time, or, until the ice had retreated far enough southwest of Lake Erie to uncover the col leading from the Maumee into the Wabash river which is about the level of the lower of the lake ridges. The approximation of these levels, namely, that of the Lake Seneca col and that of the Fort Wayne col, to the level of two prominent lake ridges is extremely suggestive of a causal connection between the two sets of phenomena.

Facts were presented illustrating the extent and character of the deposits of loam and gravel in the vicinity of these various cols, especially that at Portageville, N. Y., and of other places in the headwaters of the Susquehanna river. These facts apparently shed some light on the origin of the loess and on the deposits at the head of Chesapeake Bay, which for a long time received the glacial drainage, both from the upper part of the Susquehanna valley itself and from the vast region farther back which furnished the surplus waters of the glacial lake, Erie-Ontario.

GLACIAL PHENOMENA OF NORTHEASTERN ILLINOIS AND NORTHERN INDIANA. By FRANK LEVERETT, U. S. Geological Survey, Madison, Wisconsin.

[ABSTRACT.]

THE paper opens with an explanation of the methods of study already employed and other methods to be employed in deciphering the history of the drift. A brief discussion is given of the features and phenomena included under the term moraine as restricted in the paper. Among these features, knobs and basins, swells and sags, smooth ridges of till, bowlder belts etc., are included, but the till plain or "ground moraine" is excluded.

The moraines here described are terminal to the *ice* but not to the drift-covered areas of these states.

Four evidences of advance in the production of later moraines are cited: (1) Buried soils *in situ* between till sheets; (2) Changes in the direction of flow as shown by striæ; (3) Change in form of ice lobe as indicated by the distribution of the morainic belts and shiftings of reëntrant and lobate portions; (4) Evidence of push or advance found in the moraine itself.

The number of distinct moraines varies because of partial coalescence or local obliteration of portions of certain moraines by later advances. For this reason correlation is difficult. Aside from the difficulty cited there is an increase in the complexity in passing from older to newer moraines. In the older ones the interlobate portions are short and the moraines can be followed around continuously from one lobe to another through the reëntrant portions; but in newer moraines the terminal loops meet on opposite sides of large interlobate moraines and correlation is made only after critical study of their connections, overriding, overwash, etc.

Suggestions are made upon the subject of progressive lobation, but caution is urged against advancing general schemes too early. The study has not been carried far enough to make it possible to draw conclusions of that high order to which future extension of the work will lead.

Before the leading time-intervals in this district can be properly outlined, wider correlations must be made and erosion studies must be completed.

TOPOGRAPHIC TYPES OF NORTHEASTERN IOWA. By W J MCGEE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THERE are in the territory half a dozen distinctive types of topography: 1. The Wisconsin driftless area extends into the extreme northeastern part of the state, and exhibits a water-carved sculpture of the autogenetic

order, and as seen in plan exhibits well the characteristic features of such sculpture; but the prevailing profiles are convex in a remarkable degree. This convexity indicates and illustrates a law of water-carving not hitherto recognized, viz., *the convexity of profiles is proportional to the excess of disintegration over transportation.* Taken in connection with other phenomena, the area expresses what may be called *the law of land profiles.* 2. About the margin of the driftless area the topography is a singular hybrid between water-carved and glacial sculpture; and it is noteworthy that it is not valley-bottoms but hill-summits which were most severely abraded by ice, showing that practically the glaciers rode the hills and bridged the valleys. 3. In the southwestern part of the territory, the Pleistocene ice-sheet evidently melted rapidly while standing near base level, and the drift and loess were fashioned by sluggish currents or waves into broad plains; and these plains have since been sculptured by autogenetic processes into characteristic forms which exceptionally well illustrate that order of topographic forms. 4. The same order of forms is still better illustrated by a small "gumbo" area in the extreme southeastern part of the area overlooking the Mississippi river. This area is representative of the extensive "gumbo" plains forming a large part of the tract overridden by the earlier ice-sheet but not by the later in Iowa, Missouri, Illinois and Indiana. 5. There is a large area in the central part of the territory in which the ice both moved and melted rapidly, but at such height above base level as to permit free drainage; and the sum of conditions here was such as to give origin to a unique and anomalous configuration. The principal drainage is not in the direction of, but approximately at right or even less angles to the prevailing slopes; the water-ways flowing across or partly against the general slopes do not seek the lowest lines, but frequently avoid low-lying plains and valleys and flow in narrow cañons cleaving the axes of long ridges and dividing high plateaus; and the uplands are traversed by elongated ridges and systems of elliptical hills separating lower plains to such an extent that the whole surface over an area of 3,000 or 4,000 square miles takes on a Titanic ice-moulding as distinctive as the flutings and striæ of ice-worn ledges. These unique ice-moulded ridges and swells approach the aasar of Sweden and the kames of Ireland in form, but are more regular in arrangement and are also unique in composition—their materials being loess, sometimes fossiliferous,—and on the whole are *sui generis;* and it is proposed to retain for them the aboriginal designation *paha.* 6. There is a large area in the northwestern part of the territory over which the ice melted so slowly that floods were scarcely formed, and over which the ice moved sluggishly in the later stages; and its configuration gives a monotonous plain of low relief, over which rivers and streamlets wander in ill-defined channels of little depth between rounded slopes of boulder-dotted drift.

In this varied topography and in the associated deposits, there is recorded a singularly clear and complete history of the Pleistocene of central United States, which is set forth in detail elsewhere.

THE PETROLEUM BELT OF TERRE HAUTE. By Prof. C. A. WALDO, Terre Haute, Ind.

[ABSTRACT.]

BRIEF history of oil in Terre Haute.

Brief summary of comparative locations and depths of wells prosecuted to a conclusion.

From the two successful wells and eight failures, an attempt to show the probability of the following conclusions:

1. That oil in the Terre Haute deposit lies above 1230 feet below the level of the Vandalia R. R. at the Union Depot.

2. That the belt is about 1000 feet wide.

3. That the belt is an anticlinal running from one-half a point to a point south of east and north of west.

4. That the rock of this anticlinal is of deep-sea origin.

5. That the strata above lie upon it uncomformably.

6. That the overlying strata are first the Marcellus or Genesee shale and above this the Knobstone group.

7. That the oil rock is Corniferous or Niagara.

8. That the subsequent strata are of shallow water origin.

9. That the direction of the rock conforms to the geology of the locality and its exceptional character.

10. That a series of parallel waves probably exists.

11. That natural gas will probably be found in paying quantities.

SECTION OF THE MAKOQUETA SHALES IN IOWA. By Prof. JOSEPH F. JAMES, Ass't Paleontologist, U. S. Geol. Surv., Washington, D. C.

[ABSTRACT.]

ABSENCE of very certain and definite information, in relation to the Makoqueta shales in Iowa, made it desirable to visit and study the locality where they were exposed. But it was first necessary to find out where the locality was. Inquiry developed the fact that the Post Office Lattners, Dubuque Co., Iowa, was where the shales were exposed, and that this locality was one mile from the station *Graf*, on the Chicago, St. Paul and Kansas City R.R.

The best locality was found along the line of the railroad, where a cut had been made in the rocks, exposing about thirty-one feet of alternating shales and limestones, in the following sequence, from above downwards.

		feet.
No. 18.	Alternating shales and limestones	8
" 17.	Limestone formed of finely comminuted shells, a few perfect	1

			feet	
No.	16.	Shale in thin laminæ,	1	9′
"	15.	Limestone with Orthoceras, very abundant,	1	
"	14.	Shale, like No. 16,		8′
"	13.	Shale with Orthoceras,		4′
"	12.	Shale,		4′
"	11.	Limestone like No. 15,		5′
"	10.	Shale with Orthoceras, like No. 13,		6′
"	9.	Limestone with Orthoceras like No. 15,	1	
"	8.	Shale with graptolites and small shells,		8′
"	7.	Comminuted shells with Murchisonia,		3′
"	6.	Shale with comminuted fossils, similar to No. 8,		9′
"	5.	Comminuted shells with a few perfect ones—mostly gasteropods,	2	
"	4.	Shale (blue) with graptolites and lingulæ,	3	
"	3.	Shale, with Hyolithes in great abundance,		3′
"	2.	Shale with graptolites, etc., like No. 4,	6	4′
"	1.	Covered, probably shales like No. 2,	3	
		Total,	31°	3′

Certain species of fossils were abundant, among them Orthoceras. It will require study of the material collected to give any details of the organic remains. Graptolites were, in certain beds, found in an excellent state of preservation. In rock above the top of the section as given, are found *Leptæna* and other Brachiopoda, some species being found in chert. The rocks of the series have, probably, a thickness of from 100 to 150 feet.

Field studies of hornblende schist. By Prof. C. H. Hitchcock, Hanover, N. H.

[ABSTRACT.]

Refer to theory of petrographers that this schist is derived from augite rock in some form.

Brief description of a particular range of hornblende schist following Connecticut river at Hanover, N. H., and show that the physical structure of the mass carries out the idea that this band of schist originated in an eruptive diabase.

Shown by disturbances in the strata on both sides and by dikes and altered rocks with contact phenomena.

Age of eruption probably Silurian or post-Cambrian.

Refer to origin of foliation in the hornblende schist. Usually referred to aqueous deposition. Reasons for a different view.

REMARKS ON THE CRETACEOUS OF NORTHERN MEXICO. By Prof. C. A. WHITE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

IN these remarks the speaker referred to observations made during his late visit to the state of Chihuahua, Mexico, and to the adjacent parts of Texas and New Mexico. A small range of mountains in Chihuahua, seventy-five miles southeastward from Presidio del Norte, known as the Sierra San Carlos, was found to be composed almost wholly of much disturbed, compact, bluish limestone strata having the usual aspect of the Carboniferous limestones of the great interior region. They were found, however, to contain cretaceous fossils from top to bottom, the recognized species being such as characterize the Comanche Cretaceous of Texas. These strata are not less than 4000 feet in thickness, to which must probably be added 500 feet of similar strata at their base which are so much altered as to render their contained fossils undeterminable. All these strata rest with apparent conformity upon 2000 feet of stratified metamorphosed rocks of undetermined age; and the latter rest upon a mountain core of crystalline granitic rock. Upon the top of this series rest with apparent conformity 700 feet in thickness of only slightly altered strata, which contain characteristic fossils of the Colorado Cretaceous group.

The isolated mountain near Presidio del Norte was also found to be composed of the Comanche limestone; and lying upturned against its southern base and extending far to the southward, is a great thickness of shaly strata, succeeded by sandstones, the former bearing fossils of the Colorado Group, and the latter those of the Pierre-Fox Hill Group. The Laramie appears also to be present in that region, and the speaker estimated the total thickness of the Cretaceous seen by him in Chihuahua to be not less than 10.000 feet.

In the Chinate mountains in Texas, about twenty-five miles north of Presidio, the bluish Comanche limestone rests conformably upon carboniferous limestone, the color and character of both being so similar that they are distinguishable only by their respective fossils. Here of course both the Jura and Trias are absent. In both the Chinate and the San Carlos Mountains, the Comanche limestone is silver-bearing at its base.

Cretaceous rocks were observed at several points in Lincoln county, New Mexico, between the Rio Grande and the town of White Oaks, a distance of about eighty miles, but along the greater part of the route Carboniferous rocks only are exposed. No rocks of either Triassic or Jurassic age were observed on this route, the Carboniferous immediately underlying the Cretaceous, when the latter was found to rest upon any clastic rock. No cretaceous rocks were seen here that are thought to be older than the Dakota Group; that is, the Trias, Jura and the Lower Cretaceous all seem to be absent in this part of New Mexico.

THE PITS AND DOMES OF MAMMOTH CAVE. By Rev. HORACE C. HOVEY, Bridgeport, Conn.

[ABSTRACT.]

THERE are five strongly marked tiers in Mammoth Cave indicating as many periods of cavern history. There are also vertical shafts that cut through all these tiers. These are called pits or domes according to the visitor's point of observation. "Crevice Pit" went by that name for thirty years before it was discovered to be what is now called the Mammoth Dome. Some of these domes have been enlarged into spacious halls. A noble specimen is the "Chief City" said by Bayard Taylor to be "800 feet long, 300 feet broad, and 125 feet high, and to cover between four and five acres." It has just been accurately measured and is 450 feet long and 130 feet wide, and covers one and one-third acres.

Omitting mention of isolated pits, attention is directed now to the region of pits and domes near the one styled "The Bottomless Pit." It is reached by an aperture behind the monolith called the Giant's Coffin. The path leads under the Main Cave. Before getting to the Bottomless Pit we

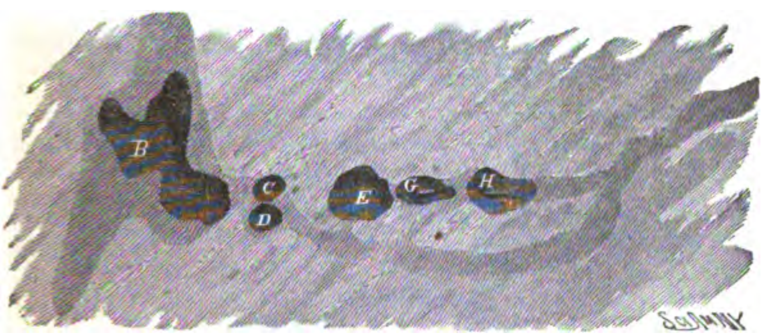

FIG. 1.—UPPER ORIFICES OF THE PITS.

enter a low passage to the left and cross the "Covered Pit" a chasm overlaid by loose slabs of limestone. The writer was the first visitor to cross this and explore what lay beyond. That was ten years ago, and no visitor is known to have crossed since till Mr. Ben Hains did so last April. He also measured the pits. The covered pit is 47 feet deep. One that is provisionally called Pit No. 2 is an oval 10 by 20 feet in diameter. Its first (or false) bottom is 37 feet below the top. Through a hole in this floor the plumb-line went 43 feet before resting, making a total of 80 feet. Pit No. 3 was found to be 30 feet deep beneath a dome equally high. A black spot in the floor attracted the guide's attention who threw a fireball down, and it was afterward measured and 59 feet had to be added to the previous 30 making 89 in all. The pits that I called Scylla and Charybdis in 1879 are separated by a very narrow natural bridge, and Mr. Hains finds them to be in reality parts of one chasm. I measured Scylla by a cord. It is 135

feet deep. Mr Hains found Charybdis to be but 79 feet deep. Beyond the latter is the edge of the Bottomless Pit that is farthest from where visitors cross by a bridge. Going back to a point near the Fat Man's Misery I followed a narrow crevice by which a point was gained near the bottom of the Bottomless Pit, whence we saw the smoke emitted through an opening into Charybdis. This led me to suspect that all the pits thus singularly clustered together are united with each other. The truth of my conjecture is confirmed by Mr. Hain's recent discoveries. This gentleman, aware of what I had done, made another and a successful attempt to reach the very lowest level. He entered an opening from the room called "Great Relief," and by following for half a mile a tortuous passage emerged into

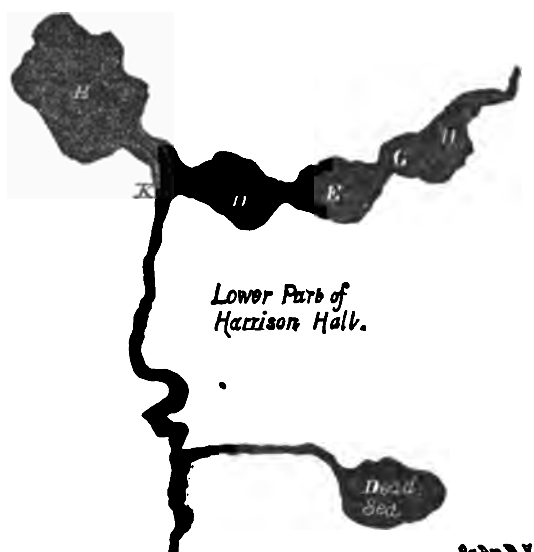

FIG. 2.

Charybdis. He found, as had been surmised, that all these seven or eight pits unite to form a magnificent hall varying in width from 10 to 50 feet, and in height from 85 to 185. The floor is uneven, rising in high and pointed hills between the pits above. It is also very muddy, being full of water in the rainy season which is drained through River Hall. The last part of the long chasm is over a floor of loose rounded fragments of sandstone. Here in the walls were found fossils. The broadest part of the hall is below the Bottomless Pit where it resembles some vast cathedral. The greatest depth of the above pit is 94 feet, 6 inches. Directly under the bridge it is 79 feet. Snowy masses of fungus hang from the bridge. If we add the height of Shelby's Dome and the intervening space we have a

sum total of 159 feet. We do not consider it as yet proved that Gorin's Dome is joined with the rest; but it is demonstrated that the others form

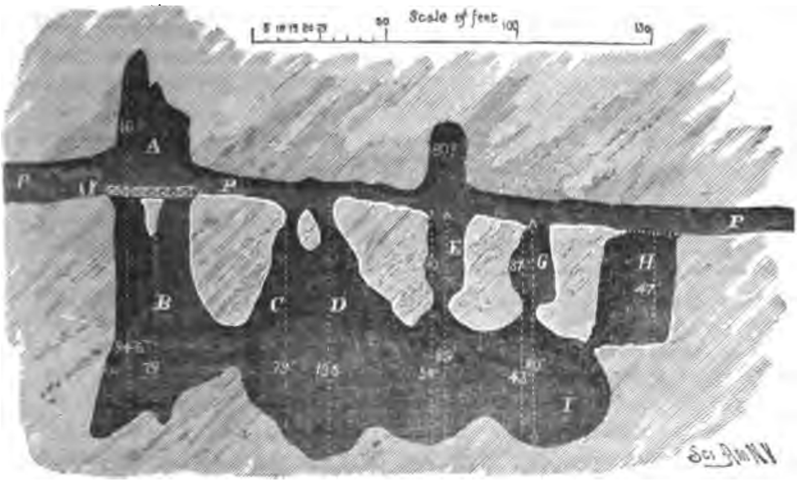

FIG. 3.—VERTICAL SECTION OF HARRISON'S HALL.

an enormous and superb room which we suggest should be called "Harrison's Hall" in honor of the President of the United States.

EXPLANATION TO CUTS.

A, Shelby's Dome; *B*, Bottomless Pit; *C*, Charybdis; *D*, Scylla; *E*, Pit No. 3; *G*, Pit No. 2; *H*, Covered Pit; *I*, Sandstone Debris; *K*, Lower entrance to the Hall; *P*, General Pathway.

TWO NEW FAUNAS FROM THE LOWER CRETACEOUS FORMATION OF TEXAS: (*a*) CAPRINA LIMESTONE FAUNA, (*b*) THE SHOAL CREEK LIMESTONE FAUNA. By R. T. HILL, University of Texas, Austin, Texas.

ON THE ATTRACTIVE SCENERY OF OUR OWN LAND. By Prof. ALBERT S. BICKMORE, American Museum, New York, N. Y.

THE IRONDEQUOIT GLACIER. By CHARLES R. DRYER, Fort Wayne, Ind.

THE MORAINES OF THE WABASH-ERIE REGION. By CHARLES R. DRYER, Fort Wayne, Ind.

THE HISTORY OF THE FORMATION OF THE GREAT LAKES. By Prof. J. S. NEWBERRY, New York, N. Y.

NOTES ON A KANSAS SALT MINE. By ROBERT HAY, Junction City, Kans.

CASTS OF SCOLITHUS FLATTENED BY PRESSURE. By ATREUS WANNER, York, Pa.

ORIGIN OF BOULDER PAVEMENTS AND FRINGES. By Prof. J. W. SPENCER, University of Georgia, Athens, Ga.

ON THE ORIGIN OF DIAGONAL TRENDS IN THE EARTH'S CRUST. By Prof. DANIEL S. MARTIN, New York, N. Y.

PRESERVATION OF GLACIATED ROCKS IN WORCESTER. By H. T. FULLER, Worcester, Mass.

NATURAL GAS IN FREDONIA, N. Y.; DIMINUTION IN SUPPLY OF GAS. By Prof. H. T. FULLER, Worcester, Mass.

TRAP DIKES IN THE REGION ABOUT LAKE CHAMPLAIN AND THE ADIRONDACKS. By J. F. KEMP, Cornell University, Ithaca, N. Y.

THE MASTODON OF KENT. By EDWARD JONES, Chatham, Ont.

SECTION F.

BIOLOGY.

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ADDRESS

BY

PROFESSOR GEORGE L. GOODALE,

OF HARVARD UNIVERSITY, CAMBRIDGE, MASS.,

VICE PRESIDENT, BIOLOGICAL SECTION.

SOME RECENT INVESTIGATIONS RELATIVE TO CELL-CONTENTS.

In the Department of Biology, there are three subjects of transcendent interest, namely: protoplasm, or living matter, development and adaptation. In fact the interest in some phases of these subjects is now so general and deep, that the special students in this department feel that they have to a great extent the sympathy and coöperation of the public at large. This interest renders possible the construction of such commodious laboratories as this, the latest acquisition of the University of Toronto, in which we are now permitted to meet. The generous halls and adequate equipment of this laboratory and other biological laboratories throughout our country and Europe, testify to the existence of a wide-spread belief that the New Natural History has much to learn and very much to teach in regard to the great problems of life.

In the annual gatherings of the members of our section, for the exchange of views and for better fellowship, it has been found expedient for us to look at one or the other of these three subjects at the outset of our work, in a somewhat broad and yet special manner.

Your chairman for the present year asks the privilege of selecting as his topic for the introductory address, the first of the subjects mentioned. You are invited to examine the more recent additions to our knowledge of protoplasm, restricting the examination to discoveries in the field of botany.

Whether we consider protoplasm, or the living-matter of plants and animals, from the point of view of physics, of chemistry, of

physiology or of philosophy, we have before us a topic which has received and which continues to receive the most assiduous attention. Hence its literature, though comparatively recent, is appallingly voluminous, and any attempt to treat the subject, or any considerable part of it exhaustively within the limits properly imposed upon introductory addresses, would result in annoyance to you and utter discomfiture for me. Apropos of this, I am reminded of a series of experiments upon protoplasm, conducted in a German laboratory, which will illustrate the embarrassment which the case presents. The study to which I refer was with regard to certain organisms of very low grade. At a given period in the life of these organisms, their microscopic masses of protoplasm become confluent in such abundance that sufficient material can be procured for experiments on a large scale. In the special investigation referred to, a considerable quantity of protoplasm, obtained in this way, was subjected to enormous pressure. You can anticipate the result; there remained behind only a shrunken residue of what we may call, without figure of speech, the most juiceless and the dryest of husks.

This natural result of extreme compression has stared me in the face during the preparation of the present address. A similar result is more than likely to follow my attempt to bring within very narrow limits the subject which I have chosen for your consideration.

The word protoplasm was coined by Hugo von Mohl in 1846 to designate certain active contents of the vegetable cell. We shall gain in clearness of vision by letting our glance rest first on the results of investigating vegetable cells and cell-contents, anterior to von Mohl's time, in order that we may see some of the steps by which this term was reached by him.

The compound microscope was not applied seriously to the examination of the structure of plants until about fifty years after its discovery by Drebbel. In 1667 Robert Hooke of England published an account of his investigations of minerals, plants and animals under the microscope, and gave excellent illustrations of what he thought he saw. His first reference to the structure of plants is in his description of charcoal, and this is followed by a good account of common cork. In these brief and fairly accurate descriptions, the author makes use of the word "*cell*," applying the term to the cavities in charcoal and in cork.

Hooke's interesting treatise was soon followed by two remarkable

memoirs, one by an Italian, the other by an Englishman. Malpighi of Bologna sent to the Royal Society of London in 1670 a work entitled *Anatome Plantarum.* The published volumes bear the dates 1675 and 1679. At the period these volumes were in the hands of the Royal Society, Nehemiah Grew, Secretary of the Society, was engaged in work almost identical with that of Malpighi, but there is no good reason to believe, as was formerly intimated, that he was indebted to Malpighi for any of the statements which he published as his own. It is, however, best for us to consider these two works together. By Grew the term "cell" appears to have been applied to the cavities in what we may term the softer tissues of the plant. To him, cells were much like the cells of a honey-comb, and he does not at any time seem to have suspected that cells could be modified into other histological elements.[1] There are, to be sure,

[1] "Next to the *cuticle*, we come to the *Parenchyma* itself, the *part* through which the "*Inner Body*, whereof we shall speak anon, is disseminated; for which reason I call it the "*Parenchyma*. Not that we are so meanly to conceive of it, as if (according to the "stricter sense of that word) it were a meer concreted *Juyce*. For it is a body very cu-"riously *organized*, consisting of an infinite number of extreme small *Bladders*, as in "Tab. 1 is apparent."—*The Anatomy of Plants* by Nehemiah Grew, M. D., 1682, page 4.

"I shall conclude this discourse with a further illustration of the *Texture* of the *Pith*, "and of the whole *Plant*, as consequent thereupon. I say therefore, (and I have given "some account hereof in the *Anatomy of Roots*) that as the *Vessels* of a *Plant*, sc. the *Aer-*"*Vessels* & the *Lymphæducts*, are made up of *Fibres;* according to what I have in this "Discourse above said; so the *Pith* of a *Plant*, or the *Bladders* whereof the *Pith* con-"sists are likewise made up of *Fibres*, which is true also of the *Parenchyma* of the "*Barque*, and also of the *Insertions* in the *Wood*. Yea, and of the *Fruit*, and all other "*Parenchymous Parts* of a *Plant*. I say, that the very *Pulp* of an *Apple*, *Pear*, *Cucumber*, "*Plum*, or any other *Fruit*, is nothing else but a *Ball of most extreme small transparent* "*Threds* or *Fibres*, *all wrapped & stich'd up* (though in divers manners) *together*. And "even all those *Parts* of a *Plant*, which are neither formed into visible *Tubes*, nor into "*Bladders*, are yet made up of *Fibers*. Which, though it be difficult to observe, in any "of those *Parts* which are closer wrought and principally in the *Insertions* of some "*Trees*, yet in the *Pith*, especially of some *Plants*, which consisteth of more open *Work*, "they are more visible, which introduceth the observation of them in all other *Paren-*"*chymous Parts*. so in the Pith of a *Bulrush* of the *common Thistle* & some other "*Plants;* not only the *Threds* of which the *Bladders*, but also the single *Fibers* of "which the *Threds* are composed, may sometimes, with the help of a good *glass*, be "distinctly seen. Yet one of those *Fibres* may reasonably be computed to be a Thou-"sand times smaller than a *Horse-Hair*."

"The *Fibrosity* of the *Parenchyma* is also visible in some *Woods*, in which it is appar-"ently mixed with the *Lignous Parts*, not only by *Insertions*, but *per minimus Partes* "*organicas*. That is to say, the *Parenchymous Fibres*, like smaller *Threds*, are either "*wrapped round about* both the *Lignous & the Aer-Vessels* or at least *interwoven* with them "and with every *Fiber* of every *Vessel;* as in *White Ash* or *Fir-Wood*, with an advanta-"gious posture & light, may be observed.

"Whence it follows that the whole *substance*, or all the *Parts* of a *Plant*, so far as "*Organical*, they also consist of *Fibres*. Of all which *Fibres* those of the *Lymphæducts*, "run only by the *Length* of the *Plant*, those of the *Pith*, *Insertions* & *Parenchyma* of the "*Barque*, run by the *breadth* or horizontally: those of the *Aer-Vessels* fetch their cir-"cuit by the *Breadth*, and continue it by the *Length*."— *The Anatomy of Plants by Nehemiah Grew*, 1682, pp. 120 & 121.

a few ambiguous expressions which might indicate that both he and Malpighi held a somewhat different view, but a strict construction of their text compels us to believe that they did not regard the vegetable cell as in any true sense a unit of structure: furthermore it is almost certain that neither Malpighi nor Grew recognized as we can now the multifarious forms of vessels, fibres, long cells and the like, as referable to a common source. There is always a strong temptation to read in an old text some meaning which squares with our own notions, and one is greatly tempted to think that these assiduous investigators, Grew and Malpighi, detected the relationships which we know exist between the different elements of vegetable structure. But after giving them the benefit of every doubt, one fails to find in their writings any recognition of such affinities. On the contrary, these investigators were engaged in a study which naturally led them away from such conceptions: they were busy with descriptive work, outlining the arrangement of tissues in all organs of the plant which their knives could reach. They did not even break up the tissues into elementary parts, but they described and delineated with great skill the tissues as they were displayed in sections. Is it not incredible that these first works on vegetable structure, prepared only a few years after the earliest application

"By which means, the said *Parenchymous Fibres*, in fetching their *horizontal circles*, do "thus *weave*, and make up the *Bladders* of the *Pith* in *Open Work*. And the same *Fibre*, "being thence continued, they also *weave* & make up the *Insertions*, but in *Close-Work*. "Betwixt which *Insertions*, the *Vessels* being likewise transversely interjected, some of "the same *Fibres wrap* themselves also about these; thus *tying* many of them together, "and so making those several *Conjugations & Braces* of the *Vessels*, which I have form-"erly described. And as some of these *horizontal Fibres* are *wraped* about the *Vessels*, so "also about the *Fibres* whereof the *Vessels* are composed. By which means it is, that all "the *Fibres* of the *Vessels* are *tacked* or *stitched* up close together into one coherent Piece, "Much after the same manner, as the *Perpendicular Splinters* or *Twigs* of a *Basket* are "by those that run in and out *Horizontally*. And the same *Horizontal Fibres*, being "still further produced into the *Barque*, they there compose the same *work* over again "(only not so *open*) as in the *Pith*.

"So that the most unfeigned & proper resemblance we can at present make of the "whole *Body* of a *Plant*, is to a piece of *fine Bone-Lace*, when the Women are working "it upon the *Cushion*, for the *Pith*, *Insertions* & *Parenchyma* of the *Barque*, are all ex-"treum Fine & Perfect *Lace-Work*; the *Fibres* of the *Pith* running *Horizontally*, as do "the *Threds* in a Piece of *Lace*; and bounding the several *Bladders* of the Pith and *Barque* "as the *Threds* do the several *Holes* of the *Lace*, and making up the *Insertions* without "*Bladders* or with very small ones, as the same *Threds* likewise do the *Close* parts of "the *Lace*, which they call the *Cloth-Work*. And lastly both the *Lignous* and *Aer-Ves-*"*sels* stand all *Perpendicular*, and so cross to the *Horizontal Fibres* of all the said *Pa-*"*renchymous Parts*, even as in a Piece of *Lace* upon the *Cushion*, the *Pins* do to the "*Thred*. The *Pins* being also conceived to be *Tubular* and prolonged to any length "and the same *Lace-Work* to be wrought many Thousands of times over & over again "to any thickness or hight according to the hight of any *Plant*. And this is the true *Text-*"*ure* of a *Plant* and the *general composure* not only of a *Branch*, but of all other parts "from the *seed* to the *seed*.—*The Anatomy of Plants, by Nehemiah Grew*, 1682, p. 121.

of the compound microscope to the study of plants, should have remained for almost one hundred and fifty years the only comprehensive treatises on the subject? But the most charitable inquirer fails to find during that long period any other works of importance on vegetable anatomy.

Near the close of the last century, at a period characterized by activity in many departments of speculative inquiries, the subject of vegetable structure again excited considerable attention, but little substantial advance was made. In 1804, the Royal Society of Sciences at Göttingen[1] proposed for competition, certain questions relative to the structure and the mode of growth of tissues. The chief contestants for this prize were Link, Rudolphi, and Treviranus. The memoirs of the first two received prizes, that of the latter, honorable mention. The names of others should be referred to as having worked at or about this time, in the same field, namely, Bernhardi, Mirbel and Moldenhawer, the latter making a great advance in certain directions. But to all of these whom I have mentioned, including the winners of the prize, the important questions seemed to be, how are the structural elements distributed, rather than how they are related to each other in manner of growth and as respects their origin. With the cell-contents they had comparatively little to do; they were busy with the constituents of the framework.

There seems to have been a strong suspicion on the part of some botanists during that period, that all this study of the skeleton of the plant failed to go to the bottom of the question. The only wonder is that with their scanty and untrustworthy chemical appliances and with their very imperfect lenses they accomplished so much. May I remind you that the element iodine which is the most important reagent in the examination of the contents of vegetable cells was not employed until the year 1812; and, further, that no good achromatic and aplanatic lenses, of even moderately high power, were constructed until 1826.[2]

Noting the more important discoveries of the next period in their order, we come first upon that of the nucleus of vegetable cells by Robert Brown in 1833, and one mode of cell-division by Mohl in 1835. In 1838 the eccentric Schleiden published his contributions to Phytogenesis in which he states substantially that

[1] Königliche Gesellschaft der Wissenschaften zu Göttingen.

[2] Æpinus and Van Deyl had nearly succeeded more than twenty years earlier.

cells of plants can be formed only in a fluid containing as chief ingredients, sugar and mucus ("schleim"). By this latter term he designated the nitrogenous matters taken collectively. At his touch all disguises fell, and for the first time the vegetable cell was distinctly recognized as a unit of structure always serving as the common basis for the formation of the innumerable shapes of the structural elements.

Next comes the master, Mohl. Armed with the best optical appliances procurable, familiar with the use of the chemical reagents then at command, and accustomed to accurate research, he reviews his own earlier work and that of his contemporaries, making rapid advances in the knowledge of the contents of the cell. In 1844 in a paper on the circulation within vegetable cells, he speaks of the living mass in each active cell, and distinctly recognizes it as that which is the treasury of stored energy and the vehicle of energy under release. He describes it as that which builds shapely forms out of unformed matter and at first hands. This substance he names *protoplasma*.[1]

If we look at the handbooks of botany just before this date of the early forties, we find references to "coagulable" matters (Treviranus) and the like. The chemical instability of the substance within cells was suspected of having much to do with its activity, but almost all of the notes, as well as those upon the same subject found here and there in philosophical writings of the latter part of the last century, are based on pure speculation. The scientific recognition of a physical basis of vital activity must be credited to Schleiden and Mohl.

The term protoplasm was at once adopted by Schleiden as a good substitute for the indefinite and misleading word *schleim* which he had employed to designate essentially the same substance, and it became thoroughly established in scientific terminology. In 1850, Professor Cohn (and Unger in 1855) showed that the protoplasm of vegetable cells is identical with what had been described

[1] "Da wie schon bemerkt diese zähe Flüssigkeit uberall, wo Zellen entstehen sollen, den ersten, die künftigen Zellen andeutenden festen Bildungen vorausgeht, da wir ferner annehmen müssen dass dieselbe das Material fur die Bildung des Nucleus und des Primordialschlauches liefert, indem diese nicht nur in der nächsten räumlichen Verbindung mit derselben stehen, sondern auch auf Jod auf analoge Weise reagiren, das also ihre Organisation der Process ist, welcher die Entstehung der neuen Zelle einleitet, so mag es wohl gerechtfertigt sein, wenn ich zur Bezeichnung dieser Substanz eine auf diese physiologische Function sich beziehende Benennung in dem Worte Protoplasma vorschläge."—*Bot. Zeit., 1846*, p. 75.

in 1835, in animal structures, as *sarcode*, by Dujardin, and this prepared the way for the exhaustive treatise by Max Schultze in 1858. From that date on, work in the contiguous fields of botany and zoölogy has made no physical or chemical distinction between the living-matter in animals and plants. Investigators in the two fields have been mutually helpful.

Mohl, in his treatise on the vegetable cell, published in 1851,[1] gives the following account of protoplasm.

"If a tissue composed of young cells be left some time in alcohol, or treated with nitric or muriatic acid, a very thin, finely granular membrane becomes detached from the inside of the walls of the cells, in the form of a closed vesicle, which becomes more or less contracted, and consequently removes all the contents of the cell, which are enclosed in this vesicle, from the wall of the cell. Reasons hereafter to be discussed have led me to call this inner cell the *primordial utricle* (*primordialschlauch*). . . . .

"In the centre of the young cell with rare exceptions rises the so-called *nucleus cellulæ* of Robert Brown ("Zellen-kern;" "Cytoblast" of Schleiden). . . . .

"The remainder of the cell is more or less densely filled with an opaque, viscid fluid of a white color, having granules intermingled in it, which fluid I call *protoplasm*."

We must now pass without notice numerous contributions to the subject made about this time, and consider Hofmeister's description of protoplasm given in his Vegetable Cell, published in 1867.

"The substance Protoplasm, whose peculiar behavior initiates all new development, is everywhere an essentially homogeneous body. It is a viscid fluid, containing much water, having parts easily motile, capable of swelling, and possessing in a remarkable degree the properties of a colloid. It is a mixture of different organic matters among which albuminoids and members of the dextrine group are always present. It has the consistence of a more or less thick mucus and is not miscible with water to any great extent."

From these and other accounts of the same date, we see that the following points were regarded as established:— (1) All of the activities of the vegetable cell are manifested in its protoplasmic contents. (2) Protoplasm consists chemically of a nitrogenous

[1] The English translation in 1852.

basis. (3) Protoplasm has no demonstrable structure. (4) The protoplasmic contents in one vegetable cell are not connected with the protoplasmic contents in adjoining cells. (5) The nucleus and other vitalized granules in the vegetable cell are formed by differentiation from amorphous protoplasm.

It is now our duty to see in what manner these views have been modified during the last twenty or rather ten years. In describing the changes of opinion, time will not suffice for us to allude to most of the observers; a few only can be mentioned by name.

The first thesis, namely, that all of the activities of the vegetable cell are manifested in its protoplasmic contents, may be regarded as firmly established. It is at this point in our present examination when, if we had time, we should take up, one by one, the terms which have been applied to some specialized or localized parts of what Mohl and Hofmeister knew as protoplasm. We can only glance at them in passing:—thus *cytoplasma* is understood to be the mass exclusive of the granular contents of all kinds; *hyaloplasma* is the outer hyaline layer; *polioplasma* is the grayish granular part. To these terms may be added others, such as *paraplasma*, etc.

The second thesis, viz.:—protoplasm consists chemically of a nitrogenous basis, remains unchanged. But instead of regarding the protoplasmic basis as simple or one, it is now known to be exceedingly complex, and to contain numerous allied proteids, some of which can be identified in the basic mass, others in the nucleus and others still in the vitalized granules.

Researches respecting this thesis must be considered also with reference to work by two diligent investigators, Pfeffer and de Vries. The former has shown the conditions under which active protoplasm reacts in the presence of certain chemical excitants; the latter has demonstrated the relations of a part of this irritability of protoplasm to its physical constitution. But as a result of all these recent studies it becomes more and more clear that the chemical relations of the protoplasmic activities are still veiled in mystery. Botanists are receding from a position held by many only a few years ago, namely, that it is safe to use the words albuminoids and protoplasm interchangeably. Nowadays the latter term is generally restricted to morphological and physiological conceptions; the former keeps its wide chemical significance.

Just here, come also the chemical studies of protoplasm; by

Rodewald and Reinke on a large scale, by Loew and Bokorny, and by Schwarz under the microscope. All of these results compel us to recognize in protoplasm a substance of bewildering complexity of composition and constitution. Moreover, you all know how wide this field of research has suddenly become by the discovery that different microbes (which are essentially minutest masses of protoplasm) not only give rise to such diverse products, but present such diverse chemical reactions.

Protoplasm is no longer regarded by any one in any sense as a comparatively simple substance.

The third thesis, namely, that protoplasm has no demonstrable structure, has been modified in a striking manner as a result of improved appliances for research. By better methods of staining and by the use of homogeneous immersion objectives the apparently structureless mass is seen to be made up of parts which are easily distinguishable. There has been, and in fact is now, a suspicion that some of these appearances under the influence of staining agents are post-mortem changes and do not belong to protoplasm in a living state. But it seems to be beyond reasonable doubt that protoplasm is marvellously complex in its morphological and physical as well as its chemical constitution. One statement of the case is as follows:—

Under ordinary circumstances, protoplasm is composed of a mesh of inconceivable fineness, in which mesh are entangled the more liquid interfilar portions (paraplasma); so that the dry husks left in Reinke's experiment may be regarded in fact as the residue of network from which all the moisture has been expelled. But this conception of protoplasm as a mass composed of a network of minutest fibres enclosing in its meshes another substance presents, as has been well shown by some critics, great difficulties, especially when we endeavor to explain the movements within the cell. It is also very difficult to explain in any way the so-called wandering of protoplasm outside the cell wall or into intercellular spaces.

Fourth, we are to glance at the accepted statement that the protoplasmic body or protoplast, as it is called, of one cell is cut off by the cell wall from all connection with the contiguous cells. There are a few cases in which this intervening wall was formerly held to be pervious, but such cases were considered as exceptional. Now, however, as has been shown by Gardiner and others who have followed out his exact researches, there are intercommunicating

threads of protoplasm of extreme fineness between adjoining cells, and these living threads maintain a connection, sometimes direct, sometimes indirect, between one protoplasmic mass and another. This has been shown to be so widely true in the case of the plants hitherto investigated, that the generalization has been ventured on, that *all the protoplasm throughout the plant is continuous.* The formation of the dividing wall in cell division is now better understood than ever before, and our knowledge of this process lends great probability to the truth of the general statement made. It is not unlikely then that all the living matter throughout each plant is continuous, a whole, shut off only partially until the time of severing from the mother plant from the body of protoplasm there, and thus making a true chain of descent.

May I ask you to observe, in passing, how this bears on the vexed subject of individuality of plants. Brücke in 1862 declared that the living protoplasmic contents of a cell formed an elementary organism, and this idea found its fullest expression in the profound work by Hanstein in 1880. In that treatise Hanstein proposed, for the living protoplasmic contents of the cell, the term protoplast, in order to indicate its individuality. But these late researches show that these protoplasts are not only highly organized and of complicated structure, but each is bound by indissoluble ties to its nearest neighbors, each helping to form a united whole.

The fifth thesis has been completely controverted. Instead of believing as formerly that all the granules within the cell arise *de novo* from the protoplasm in which they are embedded, we are now forced to regard all of them as springing from preëxistent bodies of the same character.

Hofmeister in 1867, in an exhaustive description of the contents of vegetable cells, states distinctly that the nucleus arises from homogeneous protoplasm, and that in all cell division the nucleus must first disappear, two new ones arising in its place. The nucleus, according to him, occupied a secondary place as a derivative organ, and the chlorophyll granules were believed by him and his contemporaries to be new formations from homogeneous protoplasm under certain conditions of light, temperature and food. Researches which leave no room for doubt have shown that the nucleus, in all cases hitherto examined, springs from a preëxistent nucleus by a process of division. The process of division with its marvellous

sequence of formal arrangements of definite portions in meridional lines and in polar and equatorial masses, has been most carefully examined in almost every organ of the plant, and in connection with similar processes of cell-division in animal tissues. In no well marked case has a nucleus been observed to arise from homogeneous protoplasm, even a few doubtful instances having been lately explained satisfactorily.

The extraordinary manner in which the nucleus, both in common cell-division and in reproductive blending, carries ancestral characters and controls the distribution of nutritive materials, is as yet the greatest mystery in vegetable life.

We pass next to consider a very important change of view in regard to the other granules embedded in the protoplasmic body, known as leaf-green or chlorophyll granules. Formerly, as we have noticed, it was held that all of these sprang by a process of differentiation from the shapeless mass in each exposed cell. Researches by Schmitz on some of the lower plants, and by Schimper and Meyer on the higher, have shown that these chlorophyll granules always arise by a process of division from preëxistent granules. This fact taken by itself might not possess great interest. It is, however, known that at the growing points where leaves are developed, the cells contain in their protoplasm, granules of about the consistence and color of protoplasm itself, and these granules have the power of division, much after the fashion of the cell nucleus. But the products of such division are essentially three-fold: some of the resulting granules are colorless, like the mother granules, others become true chlorophyll-granules, while others still, in those leaves which become the leaves of the flowers and the fruit, assume colors other than green. In other words we have in these associated granules, or chromatophores, a morphology which is of the highest interest. The needs of the plant bring from this common source the microscopic organs for assimilation, for storing up starch in the form of grains, for protection and attraction. This most interesting generalization, in regard to the granules taken together, adds a new zest to the study of the developing plant and the evolving species.

It has been lately claimed by de Vries of Holland, that the sap-cavities or vacuoles in protoplasm divide in much the same way as do the granules just referred to, but this part of the subject is not yet beyond all doubt. That the sap-cavities are the birth-place of

most crystals, and that the aleurone grains are desiccated sap-cavities has been made out by several observers. But it is not clear that vacuoles divide as granules do.

What we do know beyond all reasonable question is this,— that all the working granules within the plant have sprung from preexistent granules, and that there is no break here in the transmission from parent to offspring.

Such then are some of the more important changes which have taken place with regard to our knowledge of the living contents of vegetable cells. I would gladly take the time, if it could be granted, to call your attention to certain most interesting discoveries which have been made by Pfeffer relative to the absorption of coloring agents by living protoplasm, and which have been supplemented by Campbell in regard to the nucleus. But more than this allusion is now impossible.

It is an interesting coincidence that with the substituting of the crude compound microscope for high power simple lenses about 1660, came the first works on vegetable structure, and for more than one hundred years, or until the introduction of achromatic object glasses, these works were in truth the only authoritative treatises. With the introduction of water-immersion lenses came renewed activity in this field, and with the later discovery of homogeneous immersion lenses came the results which have now been detailed. Whether we have, at these stages, more than a series of interesting and very striking coincidences, or not, we have not time now to discuss. It is enough for our present purpose to observe that, with the introduction of the cedar-oil immersion objectives, a thorough reïnvestigation of certain parts of this subject began. One may be pardoned for asking whether the objectives known as apochromatics are to open up in this field new lines of research.

Can these recent discoveries relative to the continuity of protoplasm and the genetic relationship of the associated granules (including in the widest sense, the nucleus) be made to cast any light on the question of development, as they certainly do upon the kindred question of adaptation? The answer has been given us very lately by Hugo de Vries of Amsterdam.[1] This investigator, who has done very much to clear up certain obscurities in regard to the external relations of the cell, has recently revised the

[1] Intracellulare Pangenesis, Jena, 1889.

neglected doctrine of pangenesis and applied it to the question just propounded. De Vries suggests that we divide the hypothesis of pangenesis as proposed by Darwin into two parts, as follows: (1) In every germ-cell individual characters of the whole organism are represented by material particles which, by their multiplication, transmit to descendants all of such peculiarities. (2) All the cells of the organism throw off at certain periods of development material particles which flow towards the germ-cells supplying its deficiencies.

Now, de Vries asks, whether it is not high time for us to look at the first part of this hypothesis again and abandon the hindrances which the latter part imposes. If we accept his suggestion and restate the hypothesis, in view of what has been learned relative to the nucleus and other granules (the trophoplasts) within the cell, we should then read:

In every cell at a growing part are all the elements ready for multiplication. Each protoplast possesses the organs necessary for continuous transmission: the nucleus, for new nuclei; the trophoplasts for new granules of all kinds according to the needs of the plant.

De Vries reviews all theories bearing on the question, from the so-called plastidules of Elsberg to the germ-plasma of Weismann, and then applies his hypothesis of intra-cellular pangenesis to the different parts of a single plant and to the transmission of peculiarities. The active particles recognized in Darwin's hypothesis, he terms *pangens*, and, regarding them as vehicles of hereditary characters, traces them throughout their course. He is not obliged to ask for any means of transportation for these pangens, since they work, so to speak, on the spot. They are ready at hand at the points of growth.

We must look very sharply with reference to this at two points of growth in the flowering plant, namely, the bud and the seed. Each bud with its growing point, made up of cells containing in their protoplasm the divisible granules, carries with itself all the peculiarities which have been transmitted without appreciable change. In the formation of the bud there is fission, but no blending. The cells divide, and each in turn may divide until the ultimate form of the leafy branch or flower is reached. In the leafy branch new buds form, and in their turn carry forward the ancestral peculiarities. But in the flower on the other hand, with the

formation of the ovule, all development is arrested (except in the rare cases of parthenogenesis and the like) unless the protoplasm of the embryonal sac receives a new impetus from material contributed by the pollen grain. And in this blending of parts which have developed under different external conditions, we see that there is a chance for variation to come in. Not only is there a blending of the nuclei but a sharing of the accompanying trophoplasts. How this can be applied to the lower plants and other organisms cannot now be referred to. It would not be right to hold de Vries wholly responsible for the application just given, but I ask you whether the hypothesis does not appear fruitful. It certainly seems, to me, to be likely to stimulate speculation and research in this important field.

In view of de Vries' work and of the results of recent study which I have endeavored to bring before you this afternoon, does not the following statement of Darwin possess new force?

"An organic being is a microcosm, a little universe, formed of a host of self propagating organisms, inconceivably minute and as numerous as the stars in Heaven."

PAPERS READ.

THE PALÆONTOLOGICAL EVIDENCE FOR THE TRANSMISSION OF ACQUIRED CHARACTERS. By Prof. HENRY FAIRFIELD OSBORN, Princeton, N. J.

As a contribution to the present discussion upon the inheritance of acquired characters I offer an outline of the opinions prevailing among American naturalists of the so-called Neo-Lamarckian school, and especially desire to direct attention to the character of the evidence for these opinions. This evidence is of a different order from that discussed in Weissmann's essays upon Heredity, and while it cannot be said to conclusively demonstrate the truth of the Lamarckian principle, it certainly admits of no other interpretation at present, and lends the support of direct observation to some of the weightiest theoretical difficulties in the pure selection principle.

1. We regard natural selection as a universal principle, explaining the "survival of the fittest" individuals and natural groups, and as the only explanation which can be offered of the origin of one large class of useful and adaptive characters. We supplement this by the Lamarckian principle as explaining the "origin of the fittest" in so far as fitness includes those race variations which correspond to the modifications in the individual springing from internal reactions to the influences of environment. There is naturally a diversity of opinion as to how far each of these principles is operative, not that they conflict.

2. If both principles operate upon the origin of the fittest we should find in every individual two classes of variation, both in respect to new characters and to modifications of the old: first, chance variations, or those which, with Darwin and Weissmann, we attribute to the mixture of two diverse hereditary strains; these may or may not be useful; if useful they depend entirely upon selection for their preservation. Second, variations which follow from their incipient stages a certain definite direction towards adaptation; these are not useful at the start; thus while, as they accumulate, they favor the individual, they are not directly dependent upon selection for their preservation; these we attribute to the Lamarckian principle.

My present purpose is to show that variations of the second class are of an extent and importance not suspected previous to our recent palæontological discoveries, and that the Lamarckian principle offers the only adequate explanation for them.

3. The general theory as to the introduction and transmission of variations of the second class may be stated as based upon the data of palæontology — the evolution of the skeleton and teeth.

(1) In the life of the individual, adaptation is increased by local and general metatrophic changes, of necessity correlated, which take place most rapidly in the regions of least perfect adaptation since here the reactions are greatest. (2) The main trend of variation is determined not by the transmission of the full adaptive modifications themselves, as Lamarck supposed, but of the disposition to adaptive atrophy or hypertrophy at certain points. (3) The variations thus arising are accumulated by the selection of the individuals in which they are most marked and by the extinction of inadaptive natural groups. Selection, in so far as it affects these variations, is not of single characters but of the *ensemble* of characters.

The evidence is of a direct and indirect character. The direct evidence is that by actual observation in complete palæontological series, the origin of adaptive structures is found to conform strictly to the lines of use and disuse. The indirect proof is that the natural selection of chance variations is unsupported by observation and is inadequate to explain the variation phenomena of the second class.

4. I will first briefly consider the former. The distinctive feature of palæontological evidence is that it covers the entire pedigree of variations, the rise of useful structures not only from their minute, apparently useless condition, but from the period before they appear. The teeth of the mammalia render us the most direct service, as compared with the feet, since they furnish not only the most interesting correlations and readjustments, but the successive addition of new elements. With a few exceptions which need not be noted here, all the mammalia started with teeth of the simple conical type — like the simple cusps of reptiles. Practically every stage between this single cusp and the elaborate multicusped recent molar is now known. Every one of the six main cusps of the molar of *Hyracotherium*, for example, a type of an important central stage in the ungulate dentition is first indicated at the first point of contact or extreme wear between the upper and lower molars; this point of wear is replaced by a minute tubercle, which grows into a prominent cusp. These are the laws of cusp development, as observed in every known phylum of mammalia:

(1) The primary cusps first appear as cuspules, or minute cones, at the first points of contact between the upper and lower molars in the vertical motions of the jaw.

(2) The modelling of cusps into new forms, and the acquisition of secondary position, is a concomitant of interference in the horizontal motions of the jaws.

5. The evidence, of which this is only a single illustration, has accumulated very slowly. The line of reasoning from this particular series of observations is as follows: (1) The new main variations, in the teeth and skeleton of every complete series, are observed to follow certain definite purposive lines. (2) By careful analysis of the reactions to environment which would occur in the individuals by the laws of growth— we observe

that the race variations strictly conform to the lines of these reactions. (3) We further observe that no variations of this class occur without the antecedent operation of these reactions; the working hypothesis thus stands the test of prediction. (4) We accept this invariable sequence of race adaptation upon individual adaptation as proof of a causal relationship.

6. I admit that this proof may be invalidated in several ways: (1) By showing in more extended research that these observations of sequence are inaccurate or offset by others in which there is no such sequence. (2) By showing that the Lamarckian principle, while explaining some of the variations of this class, is directly contradictory to others. (3) By showing that all these phenomena may be explained equally well or better by Natural Selection. (4) By proving independently, that the transmission of acquired characters never occurs.

I will now consider each of these cases:

First — as regards these observations. They may be examined in detail in the studies of Cope, Wortman or Ryder, and in a paper I presented to this Association last year. As the question of transmission has been generally assumed in the foregoing studies, I think it is now important to review the whole field, searching for facts which look against the Lamarckian principle, for as we have been hitherto studying with a *bias* in favor of it, some such adverse points may have been overlooked. At present, however, I can recall only a single adverse observation, that is, in the development of one of the upper cusps, the lower cusp which opposes it, and which is therefore supposed to stimulate this development is found to recede. I have no doubt others will be found presenting similar difficulties.

Second — as regards the Lamarckian principle. Several objections to the special application of this principle to the evolution of the teeth have been raised by Mr. E. B. Poulton:

A.—To the objection that the teeth are entirely formed before piercing the gum and that use produces an actual loss of tissue as contrasted with the growth of bone, it may be said that by our theory, it is not the growth itself but the reactions which produce this growth in the living tissue, which we suppose to be transmitted.

B.—To the objection that this proves too much, that the cusps thus formed would keep on growing, it may be said (*a*) that in the organism itself these reactions occur least in the best adapted structures. This proposition is difficult to demonstrate in the case of the teeth, but may be readily demonstrated in what are known as the phenomena of displacement in the carpals and tarsals where growth has a direct ratio to impact and strain. (*b*) In the organism itself growth does not take place beyond the limits of adaptation, there is, therefore, no ground for the supposition that overgrowth will take place by transmission. (*c*) Either by the Selection or Lamarckian theory development is held in check by competition between the parts; there is a limit to the nutritive supply; in the teeth, as elsewhere, the hypertrophy of one part necessitates atrophy of another.

C.—A general objection of considerable force is that we find other adaptations, equally perfect, in which the Lamarckian principle does not apply;

why then invoke it here? To this it may be said that there is no theoretical difficulty in supposing that while natural selection is operating directly upon variations of the first class, the Lamarckian principle is producing variations of the second class, and while selection does explain the former, it falls far short of explaining the latter.

D.—Finally, if Weissmann succeeds in invalidating the supposed proofs of the Lamarckian principle derived from pathology and mutilations, this will not affect the argument from palæontology and comparative anatomy, for these proofs involve two elements which are not in our theorem: (*a*) immediate transmission of characters; (*b*) transmission of characters impressed upon the organism and not self-acquired.

Third—as regards the adequacy of the selection principle to explain these variation phenomena. It is not necessary to repeat here the well-known current theoretical objections to this principle, but simply to point out the bearing of this palæontological evidence. In Weissmann's variation theory the preponderating influence must be conservative, however it may explain progressive modification, or even correlation of old characters, it does not admit that the genesis of new characters should follow definite lines of adaptation which are not pre-existent in the germ plasma. We find that new characters of the second class do follow such purposive or directive lines, arising simultaneously in all parts of the organism, and first appearing in such minute form that we have no reason to suppose that they can be acted upon by selection. The old view of nature's choice between two single characters, one adaptive, the other not adaptive, must be abandoned, since the latter do not exist in the second class.

Fourth—the most serious obstacle to the Lamarckian principle is the problem of transmission. How can peripheral influences be transmitted in the way we have outlined — now that we have such strong evidence for the continuity of the germ plasma? If acquired characters are not transmitted it is clear that the whole Lamarckian principle is undermined, and all these instances of sequence express no causal relationship. We are then, however, left without any adequate explanation of the laws of variations of the second class, and are thus driven to postulate some third, as yet unknown, factor in evolution to replace the Lamarckian principle.

PRELIMINARY REPORT ON REPRODUCTIVE ELEMENTS OF EUDENDRIUM.

By Prof. CHAS. W. HARGITT, Oxford, Ohio.

[ABSTRACT.]

EUDENDRIUM, as is well known to zoölogists, constitutes one of the genera of Cœlenterata, popularly known as hydroids. During the summer of 1887 while working in the marine laboratory under direction of Dr. H. W. Conn, I undertook, at his suggestion, a study of the genus named at the head of this paper, with special reference to the origin of the repro-

ductive elements, and also the mode of their development. This genus had been studied some years previous by Kleinenberg and Weissmann and later by De Verenne. These authors had arrived at quite different conclusions especially as to the origin of the germ cells.

As has been well known for some time from the work of Kleinenberg and others the ova of common hydra are very amœbiform. This characteristic has also been noted in Eudendrium, and has been referred to the importance of securing ample nutrition and finally to location in the gonophores.

From these facts Kleinenberg was led to the conception of the origin of the cells in the ectoderm, and this conclusion was likewise corroborated by the work of Weissmann.

My own studies incline me to a very different conclusion, namely, that the reproductive elements have their origin in the endodermal tissues. This conclusion was arrived at with no knowledge of the paper by De Verenne above mentioned, and in which he contends for the same origin. I was therefore the more particular in locating these elements, and yet submit my conclusions in the most tentative way, in view of the exceeding liability to incorrectly interpret facts observed in this very variable group, and to the exceeding minuteness of the primitive cells, and the aforementioned amœbiform characteristic.

In reference to the segmentation of the ova I was only able to find delamination as the mode by which the primitive or germ layers arise. The planula is quite like this stage in other members of this and kindred genera.

ALIMENTARY APPARATUS OF THE HONEY BEE, APIS MELIFICA. By Prof. A. J. COOK, Agricultural College, Mich.

[ABSTRACT.]

THIS paper describes (with illustrations) the anatomy and physiology of the bee's tongue, the three pairs of salivary glands, the stomach mouth and the true stomach. The nature of the special aliment of the queen, drones and larval bees is explained, and proof offered to sustain the opinion.

A NEWLY IMPORTED ELM INSECT. By L. O. HOWARD, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

AN old and well-known European bark-louse (*Gossyparia ulmi* Geoffroy) has recently been imported into the United States in four distinct localities on different species of European elms. It has spread in two of these localities — Washington and Boston — to the native elms, and promises to become a serious pest. The author gives the life-history of the species at length.

SOME PECULIARITIES OF ANTENNAL STRUCTURE IN THE DELTOIDS. By

Prof. JOHN B. SMITH, Rutgers College, New Brunswick, N. J.

[ABSTRACT.]

No noctuid group has so many structural peculiarities as that usually called *Deltoidæ*, and which cannot yet be satisfactorily separated from the *Noctuidæ*. The aborted structures of the forelegs of the males of many of the species have been described and figured by me: the peculiar antennal characters have not yet been published. The males in many of the genera have the antennæ more or less pectinated, serrate or ciliate in a manner not unlike some others of the noctuid genera. In *Philometra longilabris* the pectinations are excessively long and feathery. In the congeneric *P. serraticornis* occurs a tendency not heretofore noted—the appendages or branches of each joint are not symmetrical, *i.e.*, the pectinations are not opposite, as they are in every other species that I have examined, but are alternate and unequal; a short branch issuing from the base at one side and a long branch from the apex of the joint at the other; it is less unusual to find the branches unequal in length but yet opposite. A more interesting peculiarity is a modification at about the middle of the antennæ of the males, at the outer side, and which is supposed to be used by the male in clasping the antennæ of the female when in copulation.

In its simplest form it occurs in *Chytolita* or *Herminia*, where two of the joints have long corneous outward processes so arranged that by bending the antenna the processes are approximated so as to hold tightly anything clasped between them. In *Zanclognatha* there are three processes and three joints are involved in the modification. The central process is longest, stoutest and straight: the others are more slender, shorter and lean somewhat toward the central process. In *Megachyta*, a somewhat modified form is noted; here three joints are moniliform, and each joint has an outer short, curved, acute process. The hold here is between the antennal joints, the curved processes acting as outer ring of the band. A very much more complicated arrangement is seen in *Litognatha*, which also has the most remarkably aborted forelegs. Here five joints are involved: the first shortened, and with a little outer process; the second is distorted, a little inwardly set so as to leave a little groove outwardly; the central joint is much the larger, both broader and longer, a little *outwardly* set, with two downward corneous processes and a modification of the ordinary pectination above them; the fourth joint is simply shorter, with an outer branch only; the fifth almost normal, lacking only the outer branch of the normal pectination.

Renia has a type quite different from all the others. Here the modification is confined to two joints, but a joint below has a large tuft of hair which hides the modification and has prevented its recognition heretofore. The lower modified joint has a long upward prolongation, reaching nearly to the apex of the second modified joint. This is very much longer than any other of the antennal joints, curving inwardly so as to form a clasp between it and the upper prolongation of the lower modified joint.

Similar characters seem to occur in some Pyralid families, but no such distinctive features intended as clasping organs have been noted.

THE HORN FLY: HÆMATOBIA CORNICOLA WILL. By Prof. JOHN B. SMITH, New Brunswick, N. J.

[ABSTRACT.]

FOR two years past a fly theretofore unknown has been exciting considerable alarm among farmers. It has the rather unusual habit of congregating on the horns of cattle, and the wildest stories as to its injuries to stock were soon afloat. I have worked out the complete life-history of the fly which offers several interesting characters. The habit of spreading its wings when feeding, the fact that they remain on the cattle almost constantly, and finally their habit of clustering on the horns of the cattle when at rest, sometimes in very large numbers, are unusual. They oviposit at night and the eggs are unusually large, and laid in fresh cow dung. The entire life-history is comprised in twelve to fourteen days of which five or six are comprised in the pupa state. Numerous broods thus appear in a single season. The injury to cattle is principally seen in a decided falling off in milk and cream and in the poor condition of the steers and other butcher cattle. They never in any way injure the horns by eating or otherwise.

ON THE INTENTIONAL IMPORTATION OF PARASITES AND NATURAL ENEMIES OF INSECTS INJURIOUS TO VEGETATION. By C. V. RILEY, Ph.D., U. S. Dept. of Agriculture, Washington, D. C.

[ABSTRACT.]

THE author discusses the importance of the subject of his paper and mentions several instances in which parasites have been carried from one portion of a country to another portion of the same country in which they did not previously exist. He details also the introduction of *Microgaster glomeratus*, one of the commonest parasites of the European cabbage butterfly, from Europe into this country in 1885; but devotes the greater part of his paper to a consideration of the facts connected with the importation of the parasites and natural enemies of the fluted scale (*Icerya purchasi* Maskell) from Australia into California during the winter of 1888–9, showing that the fluted scale is an indigene of Australia in which country it does little or no damage on account of its natural enemies. This importation of parasites and predaceous insects was made by the author and his official assistants and the anticipated success is already more than assured, one of the imported species (*Vedolia cardinalis*) spreading very rapidly and cleaning out the Icerya wherever it spreads.

A BACTERIAL DISEASE OF INDIAN CORN. By Prof. T. J. BURRILL, Champaign, Ill.

[ABSTRACT.]

THE first observations upon this disease were first made by the writer in 1882, but the disease has not been fully worked out until the present season. The produce of the fields is sometimes seriously reduced by this hitherto unrecognized disease. The appearance of the affected plants and fields was described and the specific characteristics of the bacteria given. The paper is published in the transactions, for 1889, of the society for the promotion of agricultural science, and in a bulletin of the agricultural experimentation station of the University of Illinois.

A BACTERIAL DISEASE OF CARNATIONS. By Prof. J. C. ARTHUR, La Fayette, Ind.

[ABSTRACT.]

NOTES the recent discovery of a very general disease of the carnation. The earliest indication of its presence in the plant is the appearanee of transparent dots in the leaves, only to be seen by transmitted light. These spots increase and coalesce, and kill the tissues, at last the leaves dry up and the plants gradually die. Microscopic examination shows the transparent spots to be due to engorgement of the cells with bacteria. Cultures of the bacteria have been made, and the disease produced in healthy plants by applying the bacteria from a fluid culture to the surface of the leaves.

NOTES ON SEEDLINGS OF ELYMUS VIRGINICUS. By Prof. W. J. BEAL, Agricultural College, Mich.

[ABSTRACT.]

FOUR hundred seedlings of non-glaucous plants were all non-glaucous; of four hundred seedlings of glaucous plants all were glaucous save two.

REVISION OF THE UNITED STATES SPECIES OF FUIRENA. By FRED. V. COVILLE, Department of Agriculture, Washington, D. C.

[ABSTRACT.]

THE forms are grouped under three species and two varieties, as follows:

Fuirena scirpoidea, Mx.
  simplex, Vahl.
  squarrosa, Mx.
    var. *hispida*, Chapm.
    var. *pumila*, Torr.

A NOTE ON THE REGULARITY OF FLOWERS IN CALAMINTHA NUTTALII, BENTHAM. By DAVID F. DAY, Buffalo, N. Y.

[ABSTRACT.]

THE theory, that sepals, petals, stamens and pistils are the analogues of leaves, naturally suggests that the flower itself is no more than a branch, the axis of which has been suppressed or very greatly shortened. It follows that the normal or typical flower must be regular in plan, and that irregularity is the result of modification. Terminal flowers are, I think, invariably regular, no matter whether erect or pendulous; but when flowers are lateral, we may confidently look for irregularity. I know of no lateral flower, which has not, more or less irregularity. In fact when a flower, though terminal, has an horizontal position, it will usually, and perhaps always, be found somewhat irregular, in one way or another. In the case of lateral flowers, it seems probable, that the cause of their irregularity is the unequal compression to which the bud, in the early stages of its development, is necessarily subjected; some parts of the flower being thereby accelerated in their growth and other parts retarded. The dissection of the bud of any irregular flower, when it has made but little growth, will, I think, always show some evidence of the original regularity of its plan. When, however, a flower, usually lateral in its position, is produced terminally, a greater or less approach towards regularity is manifested. The "Peloria" state of *Linaria vulgaris*, Mill, is an example. The same reversion, as it may be called, to regularity, has been observed, under the same circumstances, in the Gloxinias of the conservatories. But in regard to the *Labiatae*, I do not think that, until the present time, any instance of a reversion to regularity has been recorded. In the summer of 1888, I had occasion to notice that the earliest flowers of *Calamintha Nuttallii*, Benth., a plant quite common in rocky places, along the Canadian shore of Lake Erie, were *terminal* and *regular*.

RESERVE FOOD SUBSTANCES IN TWIGS. By Prof. BYRON D. HALSTED, New Brunswick, N. J.

[ABSTRACT.]

THE investigations were prosecuted during December, 1888, and January, 1889. Reserve food materials of winter twigs are divided into carbohydrates and albuminoids. Iodine in iodide of potash was employed for the detection of starch. Starch was generally found in the pith medullary rays and wood pith of all varieties examined. This testing may be done rapidly by splitting the twigs and plunging the halves in a vessel containing the iodine. Sections for the microscope can afterwards be made as needed. The details of these experiments are given in Bulletin

No. 4 of the Iowa Experiment Station. Starch is most abundant in mature twigs. In immature branches it is confined to the outermost pith and medullary rays and mostly in the vicinity of buds. There is nothing in the quantity, quality or disposition of the starch of mature twigs that characterizes one variety of apple tree from another. The starch in a tree is not entirely renewed from year to year. Grape sugar was present in variable quantities, as were also cane sugar and dextrine.

Albuminoids were found in all living parts, especially the buds fully matured, and therefore their presence is like that of starch, a test of maturity and not for varieties. Starch is not present in mature buds, because crowded out by the more vital compounds, namely the albuminoids. Crystals of the spherical type were abundant in proximity to all growing points, irrespective of variety.

Grittiness, so-called by grafters and others, is due to a thickening of cell wall by intercalation of lignin. It is best illustrated in the large pith just below a well-matured terminal bud and particularly well seen in the pear twig.

The problem of tenderness, therefore, needs to be approached upon some other line than that of cell-structure and storage of food-materials. If a difference of structure exists, it is most likely among the protoplasmic molecules and therefore beyond the reach of the present microscopes.

Many other plants were tested in connection with the apple twigs. Cherries have only a small amount of starch—a mucilage taking its place. Starch was packed in the pith of pears, even tender sorts. In the currant and gooseberry there is but little starch in the twigs, but large quantities in the root system. The same was true of the Hercules club (*Aralia spinosa*). Willow, poplar and several other trees had no starch in twigs. The roots were not examined. Oaks were rich in starch at the base of cluster of terminal buds. Maples had a moderate amount. Elms, basswood, honey-locust and hackberry and other trees without well-formed terminal buds had but small amounts of starch near the tips, but it was in proximity to buds lower down. The bases of thorns and spines usually contain starch.

This starch gradually disappears as growth begins in spring.

A SUGGESTION CONCERNING SCIENTIFIC WORK. By Prof. WILLIAM R. DUDLEY, Ithaca, N. Y.

FERMENTATION OF ENSILAGE. By Prof. T. J. BURRILL, Champaign, Ill.

[This paper will appear in a bulletin of the agricultural experiment station of the University of Illinois.]

MODERN TEACHING APPLIANCES IN BIOLOGY. By Prof. R. RAMSAY WRIGHT, Toronto, Ont.

THE RELATION BETWEEN TEMPERATURE AND NUMBER OF VERTEBRÆ IN FISHES. By Prof. DAVID S. JORDAN, Bloomington, Ind.

THE HISTORY AND MIGRATION OF THE AMERICAN CROW IN NEBRASKA. By Prof. W. EDGAR TAYLOR, Nebraska State Normal School, Peru, Nebraska.

NOTES ON THE LOCAL DISTRIBUTION OF SOME BIRDS. By A. W. BUTLER, Brookville, Ind.

ON THE HIGHER DIVISIONS OF THE PELECYPODA. By WM. H. DALL, Washington, D. C.

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ADDRESS

BY

PROFESSOR GARRICK MALLERY,

VICE PRESIDENT, SECTION H.

ISRAELITE AND INDIAN.
A PARALLEL IN PLANES OF CULTURE.

Axioms and postulates long limited man's study of man. This hampering has been most marked in reference to America, which it was agreed must have been peopled from the eastern hemisphere, and that the languages, religions and customs found here must have been inherited from nations registered in Eurasian records. Whatever was found here was through descent or derivation, the conceptions of autogeny and of independent growth by which men in the same plane of culture act and think alike not having arisen to explain observed facts.

Many authors have contended that the North American Indians were descendants of the "ten lost tribes of Israel." Prominent among them was James Adair, whose work, highly useful with regard to the customs of the southeastern Indians, among whom he spent many years, was mainly devoted to proof of the proposition. The Rev. Ethan Smith is also conspicuous, and even the last book discussing the Indians, published last year, bearing the comprehensive title "The American Indian," favors the same theory.

The argument that the Indians are descended from the "lost tribes" is weakened by the fact, now generally accepted, that those tribes were not lost but most of the people were deported and absorbed, their traces being left during centuries, and others fled to Jerusalem and Egypt. If any large number of them had remained in a body and had migrated at any time long before the Columbian discovery, but later than the capture of Samaria in the seventh

century B. C., their journey from Mesopotamia to North America would have required the assistance of miracles that have not been suggested except perhaps in the book of Mormon.

The authors of the school mentioned have for their excuse the fact, which I freely admit with greater emphasis, that an astounding number of customs of the North American Indians are the same as those recorded of the ancient Hebrews; but the lesson to be derived from the parallel between the Indians and the Israelites is very different from that of the descent advocated.

For brevity, the term Indians may be used—leaving the blunder of Columbus where it belongs — without repeating their designation as North American, as I shall not treat of the aboriginal inhabitants south of the United States. This neglect of Mexico, Central and South America is not only to observe my own limits, but because some of the peoples of those regions had reached a stage in advance of the northern tribes. To avoid confusion, the term Israelites may designate all the nation. Although the tribes became divided into the kingdoms of Israel and Judah, when it is necessary to speak of the northern tribes they may be designated as the kingdom of Samaria. The shortest term, Jews, would be incorrect, as the people scattered through the world and called "Jews" are chiefly the descendants of the southern branch or fractional part of the children of Israel and have a special history beyond that common to them with their congeners.

The parallel presented is not selected because the two counterparts are more similar to each other than each of them is to other bodies of people among the races of the earth. I readily admit that a similar parallel can be drawn between both the Indians and the Israelites and the Aryan peoples from which I and most of my hearers are supposed to have descended. The selection is made for convenience, because this audience is supposed to be familiar with the Old Testament, so that quotations and citations are unnecessary; and also because many of them in this, the anthropologic section, are familiar with the Indians, so that the collocation of facts without a prolix statement is sufficient for comparison.

Although the Indians are divided into fifty-eight linguistic stocks and three hundred languages, and there is great variety in their manners, customs and traditions, yet there is sufficient generie resemblance between all of them to allow of typical instances, where the European civilization and missionary influence have not

effected a change or where the early authorities are reliable. It is essential to examine the other side of the parallel — the Israelites — at a period coincident in development with that of the Indians. The history and records of the Israelites must be chiefly considered regarding the times before they had formed a nationality and had become sedentary. Nearly contemporaneous with that nationality was the general use of writing, and it would appear that the era of King David would be a demarcating line. The Indians, never having arrived at the stage of nationality, though some of them (as the Iroquois and the Muskoki) were far on the road to it, and never having acquired a written language, their stage at the Columbian discovery, allowing for the differences among themselves, shows a degree of development similar to that of the Israelite patriarchal period and the early Canaanite occupation before the rule of kings.

The argument, strongly urged, derived from an alleged similarity between the Hebrew and some Indian languages, especially in identity of some vocables, is not to be considered. Perhaps the most absurd of all the coincidences insisted upon by Adair was the religious use of sounds represented by him to be the same as the word Jehovah. As the deported Israelites did not pronounce the name given in the English version as "Jehovah," and the mode of its spelling and pronunciation is at this moment in dispute—generally given as Jahveh— it would be very remarkable if the tribes of Indians supposed to be descendants of the lost ten tribes of Israel, should at this time know how to pronounce a name which their alleged ancestors did not possess or at least did not use.

Father Lafiteau was so much excited by coincidence in sound of some of the Iroquoian names and expressions with the language of the ancient inhabitants of Thrace and Lycia, that he based thereon a theory of descent. On similar grounds ancestors of the Indians have been found among the Phœnicians, Scandinavians, Welsh, Irish, Carthagenians, Egyptians, Tartars, Hindus, Malays, Chinese, Japanese and all the islands of Polynesia. It is not wonderful that, with the choice of three hundred Indian languages besides their dialects from which to make selections of sounds, some one should be likened to any other language, for any languages that are spoken can, in that manner,—*i. e.*, by a comparison of vocables—show identity of sound and a percentage of coincidences of significance. Philology now makes different rules of comparison.

It is important to establish the time when writing was first known among the Israelites, because then the traditions would first become fixed. No reliable history can exist before writing. What people remember are fables and myths; from those must be winnowed the history of the time when the people could not write. There is no reason to suppose that the Hebrew language was written at the time of the exodus though some mnemonic system might have been used. If Moses had all the knowledge of the Egyptians he could not have used any better mode of writing than their hieratic, in which it was not possible to write intelligibly any long document in the Hebrew language, simply because the advance made by the hieratic, in which the use of phonetics began, was not sufficient to be adapted to the Hebrew vocables.

There has been an attempt to show that the old Hebrew alphabet, which has been classed as partly Phœnician and partly Babylonian, was obtained from Assyria at a time before the exodus, but the theory is not yet established. Even if Assyrian characters adaptable to the Hebrew language did then exist it is not probable that the Israelite herdsmen did so adapt them with current use.

The compilers of the Old Testament, as we now have it, felt no doubt that the law could have been written on Mount Sinai. They knew how to write and so did their fathers, and it did not occur to them that there had ever been a time in which persons of the higher classes were ignorant of writing.

It is probable that in the days of Samuel the Israelites had made some progress in the art of writing. An alphabet had been known to some of them before, but a common use is of greater consequence and that depends much upon the substances used for writing, their cost and the convenience of procuring them. The people did write under David at, perhaps, about 1100 B. C.

Moses flourished about fifteen centuries before Christ, and the oldest legends relating to him are, in their present shape, four or five centuries later than his death. He did not practically organize any formal state of society, or if he did, temporarily, by his personal power, it had no direct consequence or historical continuity. The old system of clans and religion continued as before. If the legislative portion of the Pentateuch was the work of Moses it remained a dead letter for centuries and not until the reign of Josiah became operative in the national history.

The historical account undoubtedly states that Moses was, by inspiration, the founder of the Torah; but the question is, what was that

Torah? It was not the finished legislative code. The promulgation of the law at Sinai was long after described dramatically to produce a solemn impression, representing as occurring on a momentous occasion what in fact slowly and imperceptibly grew during ages.

The code now ascribed to Moses was certainly a revised code, and in an unusual sense a mosaic work. When the Israelites attained the use of writing they did as all other people in the world did when they began to use writing; *i. e.*, they wrote out their own myths, traditions and legends as they knew them at the time of writing, unless special reasons made it desirable to manipulate them. There were such special reasons in the later history of Israel, in the contests between the Elohists and the Jahvists. When the compilers belonging to the two schools produced the two versions, intermixed and confused in the books we now have, they differed from all people in history where there was a struggle for political power, if, to suit their own views, they did not color the earlier documents, long since lost, namely: the "Book of the Wars of Jahveh" and the "Jasar."

It is also certain that during the long time in which the traditions were transmitted orally, the growth of the nation's ideas produced a change in them without any fabrication or design.

Students who have devoted their lives to study the last compilation have been able to identify, by linguistic and historical exegesis, the fragments of the original traditions, the epic tales of the first documents, the theocratic deductions and the later sacerdotal visions, though the two versions appear on the same page and sometimes in the same paragraph. The results of this immense labor by the Hebraists of this generation have lately been presented by Renan in a popular form.

In addition to the linguistic and historical tests, the internal evidences, especially the antedating of conceptions several centuries (some instances of which will be mentioned) show that the books, as now received, were written long after the periods referred to in them.

The main document on the primitive age is the Book of Genesis, regarded for the reasons mentioned, not as literally historical, but as the tradition, written at a respectable antiquity, of an age that really existed. In examining it the historical part is discovered, not by belief in the miraculous, but by the proper comprehension of the mythical.

Much can be learned, from myths and legends, of the periods anterior to strict history. The Homeric epics are not history, yet they throw a flood of light upon Greek life a millennium before the Christian era. The ante-Islam tales and the Arthurian and Niebelungen romances of the Middle Ages are not true in fact, yet they are storehouses, preserving the social life of the days when they were composed and in a useful degree of the time embraced by the traditions. The generalizations derived from the details of ancient texts are truths obtained by induction.

It is expedient to make a disclaimer before entering upon the necessary comparisons of religions. I absolutely repudiate any attack upon any religion. Let us learn a lesson from the Indians, not only in tolerance but in politeness. One of the early Jesuit missionaries in Canada recounts how he pleased a Huron chief by his discourse upon the cosmology set forth in the Scriptures, and felt that he had secured a convert until the chief, thanking him for his information, added: "Now you have told me how your world was made, I will tell you how my world was made"; and proceeded to give the now familiar story of the woman falling from the sky and the turtle. He was perfectly satisfied that the priest should retain his belief with which his own, in his opinion, did not conflict. Doctor Franklin tells of a Susquenannock who, after a similar lecture from a Swedish missionary, was answered in the same manner; but this missionary became angry and interrupted the Indian, whereupon the latter solemnly rebuked him with pity: "I have listened politely to what you told me; if you had been properly brought up you would have believed me as I believed you."

Religion, as accurately defined, embraces only the perficient relations between divinity and man, and the mode in which such relations operate. Popularly it includes cosmology and theology. For present convenience the broad subject may be divided into Religious Opinions and Religious Practices.

In treating it, all religious views personally entertained must be laid aside and the study conducted strictly within the scope of anthropology. A rule of science is not to use a miraculous factor when it is unnecessary. *Nec deus intersit, nisi dignus vindice nodus.* It will be recognized as puerile to explain puzzling phenomena, as was done for ages,

> When solved complete was any portent odd
> By one more story or another god.

If experience of observed facts and of the orderly working of the forces of nature is not sufficient for any proposed study, some minds resort to the miraculous while others humbly confess ignorance.

In anthropology, the object is to study within the category of humanity. It is undoubtedly true that in their explanation of phenomena, all the peoples of the world have resorted to revelations. Every myth or teaching is directly or indirectly through revelation; but as the revelation is on both sides of the equation, it can be eliminated from any parallel. Religious writers have often explained the differences in beliefs among the various peoples of the world on the hypothesis that religious knowledge was implanted at one time in the ancestors of all those peoples, and that the divergence now found is through decay of that supernatural information.

A distinguished cardinal was rash when, admitting that the doctrine of the devil and his command of demons was not known to the Israelites until after the Babylonian captivity, he insisted that it might be divine revelation, notwithstanding its immediate source. He said that if God made Balaam's ass speak, it would also be easy for him to provide that the heathen should give correct instruction. Doubtless. But this practically means that all revelations suiting us are true and all others false. When the judgment upon the truth or falsehood of an alleged revelation is made only in accordance with the prejudices of the judge, the subject becomes too eclectic and elastic to be considered by science. It is not allowable to impress a new hypothesis to support an older one when the requisition is for facts to convert the first hypothesis into an admitted theory.

Certain it is that the assertion of revelation cannot be dealt with in this address. To raise that point acts as a clôture, cutting off all debate.

RELIGIOUS OPINIONS.

The most generally entertained parallel between the Indians and the Israelites, repeated by hundreds of writers, was that they both believed in one overruling god. This consensus, if true, would at once establish a beatific bridge of union between the two peoples, but its iris arch vanishes as it is viewed closely.

After careful examination, with the assistance of explorers and linguists, I reassert my statement published twelve years ago, that no tribe or body of Indians, before missionary influence, entertained

any formulated or distinct belief in a single, overruling "Great Spirit," or any being corresponding to the later Israelite or the Christian conception of God. All the statements of the missionaries and early travellers to the opposite effect are erroneous. Even some of the earliest writers discovered this truth. Lafiteau says that the names "Oki" and "Manito" were given to various spirits and genii. Champlain said that Oki was a name given to a man more valiant and skilful than common. "Hawaneu," reduced to correct vocables, only means loud-voiced, *i. e.*, thunder. "Kitchi Manito" is not a proper name for one god, but an appellation of an entire class of great spirits. So with the Dakota term "Wakan," which means only the mysterious unknown. A watch is a wakan. The Chahta word presented as "God" for two centuries is now found to mean a "high hill."

The Indians probably had a vague idea of some good spirit or being whom they did not worship and to whom they did not pray. They prayed and sacrificed to the active daimons, concerning whom they had many myths. It is true that in their various cosmologic myths there was some vague and unformulated being who started the machinery by which the myth proceeded; but when once started no further attention was paid to such originator. Perhaps some modern advanced thinkers have no clearer definition of a great first cause.

Praise has been lavished upon the Indians because they did not take the name of God in vain. That, however, might be because they did not have any word corresponding with the English "God" either to use or misuse, which is the fact according to the best linguistic scholars, and they deserve no more praise for avoidance of profanity than for their total abstinence from alcoholic drinks before such had been invented or imported. The terms "Master of Life," "Maker of Breath" and "Great Father" were epithets merely. Perhaps there was an approach to a title of veneration when the method of their clan system was applied to supernatural persons, among whom there would naturally be a chief or great father of the "beast gods," on the same principle as there was a chieftaincy in tribes.

The missionaries who have persistently found what did not exist are not without excuse. Wholly independent of any design to force welcome answers, an interviewer who asks a leading question of an Indian can always obtain the answer which is supposed to be

desired. The sole safe mode of reaching the Indian's mental attitude is to let him tell his myths and make his remarks in his own way and in his own language. When such texts are written out, translated and studied they are of great value. It is only within about twelve years that this has been done, to the correction of many popular errors.

It is also true that in attempting to translate the epithets men tioned, the missionaries used the word which, in their own conception, was the nearest in significance. An instructive instance was where Boscana described a structure in southern California as a "temple." It was a circular fence, six feet high, not roofed in—a mere plaza for dancing; but the dancing was religious and the word "temple" was the best one he could find, by which mistake he has perplexed archæologists who sought for the ruins.

A consideration not often weighed is that the only members of the Indian tribes who are willing to give their own ideas on religious matters to foreigners, are precisely those who are most intelligent and most dissatisfied with their old stories. There were minds among them groping after something newer and better, and it would be easy to translate their vague longings into the conception of an overruling Providence. But the people made no such advance.

The missionaries who announced that the Indians were strict in the belief in one god, were much troubled by the statement of the converted native, Hiaccomes, of Martha's Vineyard, who, having enumerated his thirty-seven gods, gave them all up. This, however, was a typical instance of the truth. The Indians had an indefinite number of so-called gods corresponding with the like indefinite number of the Elohim of the Israelites before the supremacy of Jahveh.

The Biblical religion of Israel has been popularly held to be coeval with the world, but it had its own beginning by no means archaic, after which at least four hundred years were required for its development. About a thousand years before Christ it did not exist. The religious practices of David and Solomon did not materially differ from those of their neighbors in Palestine. Not until the time of Hezekiah, about 725 years before Christ, did the Israelite religion attain to a distinct formulation. Its ordinances and beliefs advanced from crudity and vagueness to ripeness and establishment. It was a system long in growth and so could not early possess authoritative documents.

The nomad Semite believed, with other barbarians, that he lived amid a supernatural environment. The world was surrounded and governed by the Elohim—myriads of active beings, seldom with distinct proper names, so that it was easy to regard them as a whole and confound them together. Yet the power bore different names in different tribes. In some cases it was called El, or Alon, or Eloah; in other cases Elion, Saddai, Baal, Adonai, Ram, Milik or Moloch.

The Elohim, though generally bound together, sometimes acted separately; thus each tribe gained in time its protecting god, whose function was to watch over it and direct it to success.

In the transition to nationality, the Israelites adopted a national god, Jahveh, who was not just, being partial towards Israel and cruel towards all other peoples. The worship of a national god is not monotheistic but henotheistic, recognizing other gods of other peoples. The work of the later prophets consisted in restoring the attributes of the ancient elohism under the form of Jahveh, and in generalizing the religious cult of a special god.

Jahveh was not at first the god of the universe, but subsequently became so because he was the God of Israel, and very long afterwards was claimed to be the only god, mainly because the Israelites claimed to be the peculiar people. Even down to the time of the prophet Isaiah, there were intermittent conflict and co-ordination between Baal together with the other gods of Canaan and Jahveh.

The revolution accomplished by the prophets did not change expressions. The word Jahveh was too deeply rooted to be removed, and the people spoke of Jahveh as they had formerly spoken of the Elohim. He thus became the supreme being who made and governed the world. In time even the name of Jahveh was suppressed and its utterance forbidden; and it was replaced by a purely theistic word meaning the Lord. Undoubtedly the prophets, at the time of the Kings and later, taught the worship of one God, but the people were not converted to the doctrine until after the great Captivity.

When established in Palestine, the Israelites entered into communion with their Canaanite kindred and worshipped Baal. With less apparent reason they frequently bowed down to the Dagon of the Philistines and the Ashtaroth of the Phœnicians. Solomon introduced the service of the Sidonian Astarte, which was intermitted, but later, Ahab established the worship of the Sidonian divinities in the Kingdom of Samaria. It was subsequently re-adopted in the

kingdom of Judah, and not until the reign of Josiah were their altars finally demolished.

The true parallel, therefore, between the Indians and the Israelites, as to belief in a single overruling god is not that both, but that neither, held it.

In the stage of barbarism all the phenomena of nature are attributed to the animals by which man is surrounded, or rather to the ancestral types of these animals, which are worshipped. This is the stage of zoötheism. Throughout the world, when advance was made from this plane, it was to a stage in which the powers and phenomena of nature are personified and deified. In this stage the gods are anthropomorphic, having the mental, moral and social attributes of men, and afterwards having the forms of men. This is the stage of physitheism. The most advanced of the Indian tribes showed evidence of transition from zoötheism to physitheism. The Israelites, in the latter part of the period selected, showed the same transition in a somewhat higher degree than the Indians did when their independent progress was arrested.

It is needless to enlarge upon the animal gods of the Indians, or to furnish evidence that they gave some vague worship to the sun, the lightning, to fire and winds.

There is no doubt that the Israelites were for a long period in the stage of zoölotry. They persisted in the worship of animal gods: the golden calf, the brazen serpent, the fish-god and the fly-god. The Second Commandment is explicitly directed against the worship of the daimons of air, earth and water, which is known to have been common; and the existence of the prohibition shows the necessity for it, especially when formulated, after the practice had existed for centuries, by a religious party which sought to reform it.

The God of Sinai was a god of storm and lightning, which phenomena were strange to the Israelites after their sojourn in plains. The ancient local god of the Canaanites began in the exodus to affect the religious concepts of the Israelites so that they identified Jahveh with the god whose lands they were planting and whose influence they felt. Sinai was thenceforward the locality of their theology. Jahveh, through all changes, remained there as his home; he spoke with the voice of thunder and never appeared without storm and earthquake.

Another class of gods connected with beast worship and also with the totemic institution (to be hereafter specially noted) was tutelar, the special cult of tribes, clans and individuals. It was conspicuous both among the Israelites and the Indians.

Jahveh, according to all that is known, may first have been a clan or tribal god, either of the clan to which Moses belonged or of the clan of Joseph, in the possession of which was the ark. No essential distinction was felt to exist between Jahveh and El, any more than between Ashur and El. Jahveh was only a special name of El which had become current within a powerful circle, and which, therefore, was better fitted to become the designation of a national god. When other tutelar gods did not succeed, there was resort to Jahveh, probably in the early instances, because he was the most celebrated of all the tutelar gods, and the reason for that celebrity was that the most powerful of the clans claimed him as tutelar.

Hecastotheism is a title given to the earliest form of religion known, which belongs specially to the plane of savagery. In it every object, animate or inanimate, which is remarkable in itself or becomes so by association, is a *quasi* god. The transition between savagery and barbarism, as well as between the religions of hecastotheism and zoötheism connected with them, was not sharply marked, so that all their features could exist at the same time at a later era, though in differing degrees of importance.

This intermixture is found both among the Israelites and Indians. An illustration among many is in the worship of localities and of local gods. Conspicuous rocks, specially large trees, peculiar mountains, cascades, whirlpools and similar objects received worship from the Indians; also the places where remarkable occurrences, as violent storms, had been noted; and among some tribes the particular ground on which the fasting of individuals had taken place, with its accompanying dreams. The Indians frequently marked these places, often by a pile of stones; but the Dakotas, when they did not have the stones, used buffalo skulls.

In the Old Testament frequent allusions are made to a place where dreams or remarkable events occurred becoming holy. They were designated by pillars. The Israelite compilers adopted the pillar of Bethel for the same reason that required Mohammed to adopt the Caaba. They could not, while struggling for monotheism, always directly antagonize the old hecastotheism.

Future state.—The topic of a future state may be divided into

(1) the simple existence of the soul after death, (2) the resurrection of the body, and (3) the rewards and punishments in the next world.

The classical writers often distinguished two souls in the same person—one that wandered on the borders of the Styx until the proper honors had been given to the corpse; and the other was a shadow, image or simulacrum of the first, which remained in its tomb or prowled around it. The latter could be easily invoked by enchanters.

Some of the Indians thought that the souls of the dead passed to the country of their ancestors, from which they did not dare to return because there was too much suffering on the road forward and backward. Nevertheless, they believed that there was something spiritual which still existed with their human remains and they tell stories of it. Thus there are two souls, and the Dakotas have four, one of which wanders about the earth and requires food, the second watches over the body, the third hovers around the village, and a fourth goes to the land of spirits.

The Iroquois and Hurons believed in a country for the souls of the dead, which they called the "country of ancestors". This is to the west, from which direction their traditions told that they had migrated. The soul must go there after death by a very long and painful journey, past many rivers, and at the end of a narrow bridge fight with a dog like Cerberus, and some of them fall into the water and are carried away over precipices. In a manner difficult to understand, this road is all on the earth; but several of the Indian tribes consider the milky-way to be the path of souls, those of human beings forming the main body of the stars, and the dogs, which also have souls, running on the sides. In their next world the Indians do precisely the same as they customarily do here.

The Israelites believed in a doubling of the person by a shadow, a pale figure, which after death descended under the earth and there led a sad and gloomy existence. The abode of these poor beings was called Sheol. There was no recompense, no punishment. The greatest comfort was to be among ancestors and resting with them. There were some very virtuous men whom God carried up that they might be with him. Apart from these elect, dead men went to oblivion. Man's good fortune was to have been accorded a number of years, children to perpetuate his family and his memory to be kept in respect after his death.

The Indians did not believe in death as a positive state. The spirit does not wholly leave the body and the body is not resurrected. Perhaps a good instance of their belief is that of a tribe of Oregon Indians who, hearing the missionaries preach on the resurrection, immediately repaired to an old battle-field and built great heaps of stones on the graves of their fallen foes to prevent their coming up again. They did not want any of that.

Among the Israelites the resurrection of the body was a foreign idea imbibed during the captivities in Assyria and Babylonia. Perhaps the first reference made to it is in the prophet Daniel. It was not fully believed in so late as the procuratorship of Pontius Pilate.

Among the Indians privation of burial and funeral ceremonies was a disgraceful stigma and cruel punishment. There was trouble about children who died shortly after their birth, and also about those whose corpses were lost, as in the snow or in the waters. In ordinary cases of death the neglect of full and elaborate ceremonies caused misfortune to the tribe.

The story of the "happy hunting ground" among the Indians has not been generally apprehended. As regards what we now consider to be moral conduct there was no criterion. A good Indian was one who was useful to his clan and family, and was, at the time of his death, not in a condition of violating the clan rules, for which the Polynesian word tabu has been adopted. The moral idea of goodness of a Pawnee chief is to be a successful warrior or hunter. The actual condition at the time of death decided the condition in the future life far more than any conduct during life. In the portions of the continent where the scalp was taken, the scalped man remains scalped in the world of spirits, though some tribes believed that scalping prevented his reaching that world. If he had but one leg or eye here, he had but one leg or eye afterwards. In tribes where they cut off the ears of slain foes the spirit remains without ears. A special instance is where the victim was considered too brave to be scalped, but the conquerors cut off one hand and one foot from the corpse to keep him from inflicting injury upon the tribe of the conquerors in the next world. If an Indian died in the night some of the tribes thought that he remained in total darkness ever afterwards.

One of the most curious of their beliefs was in connection with drowning and hanging, the theory being that the spirit (which was

in the breath) did not escape from the body. This doctrine was made of special application to prevent suicide which was generally performed either by hanging or drowning, the deduction being that suicides could not go to the home of the ancestors.

It is probable that the various trials by which the spirit is supposed to reach the other world, which were very numerous in the different tribes, were invented to secure confidence in the absence thereafter of the ghosts of the dead, because the same difficulty would attend their return. As without the assistance of the mortuary rites, given at the time of death and sometimes for considerable periods afterwards, the ghosts would not be able to reach their final home, there being no repetitions of those rites to assist their return, their absence was secured. Fear of the ghosts, not only of enemies but of the dearest friend, generally prevailed. After a death all kinds of devices were employed to scare away the spirit. Sometimes a new exit was cut through the wigwam, through which the corpse was taken, and afterwards filled up, it being supposed that the spirit could reënter only by the passage through which it went out. Sometimes the whole wigwam was burned down. There was always a long period which travellers called that of mourning during which drums and rattles were used to drive away the spirits. After firearms were obtained they were discharged in and around the late home of the deceased with the same object. The loud cries of so-called lamentation had probably a similar origin, and this is more marked when the lamenters were strangers to the dead, and even professionals, not unlike the Irish keeners.

In this general connection it is proper to allude to the common abstinence from mentioning the true name of any dead person. This is more distinct than the sociologic custom where the man's true name should not be used in his life except on special occasions. There was some fear that, by calling his name, he might come back.

It would be wrong to accuse the Indians of want of feeling indicated by their horror of the dead. In one of the most ancient accounts — that of Cabeza de Vaca — it is declared that the parents and other relatives of the sick show much feeling while life remains but give none to the dead—do not speak of them or weep among themselves or make any signs of grief or approach the body. This domestic reticence is entirely different from but not antagonistic to the obligatory mortuary rites which were practised.

To secure the living from the presence of the spirits of the dead was the first object, and the second was to assist those spirits in the journey to their destination. These were the prevailing ideas of all the mortuary customs of the Indians. It may be true that there was in some cases, though missionary influence is to be suspected, a belief that there were two different countries (sometimes called towns) in which the bad and the good would severally remain, but that was not of general acceptance. There was but one future country, and the only question was whether the spirits got there or not. There was no hell.

The Israelites, in their sacred books, do not show the influence of fears or hopes concerning a future state with reference to individual morality. Among them death was not an inevitable necessity, but an infliction as a punishment and their signs of mourning were acts of penitence and contrition, with the idea that the survivors might have been the cause of the death. All deaths were classed with public calamities, such as pestilence, famine, drought or invasion, being the work of an enemy—perhaps a punishing god, perhaps a daimon or a witch. They regarded it so great an evil to die unlamented that it was one of the four great judgments against which they prayed, and it was called the burial of an ass. It is however questionable whether rites attending upon death were not with them similar in intent to those of the Indians; *i. e.*, to provide, by means of those rites, for the future welfare of the departed, rather than in accordance with our modern sentiment, to show respect. Passages of the Old Testament may be noted, *e. g.*, the one telling how the bodies of Saul and his children were rescued from Bethshan and taken to Jabesh where they were burned and the bones buried. The ceremony in this case and others seems to have been the burning of the flesh and the burial of the bones, as was frequently done by the Indians on occasions of haste, without waiting as usual for the decay of the flesh, the later gathering of the bones being at stated periods of years.

There is no evidence that the Israelites feared the corpse and its surroundings beyond that to be inferred from the ordinances concerning pollution.

RELIGIOUS PRACTICES.

There should always be a cross reference in thought between what in time became a religious practice and the earlier sociology,

which will be mentioned in its place, with which it was closely connected.

Josephus remarks about the Israelites that "beginning immediately from the earliest infancy nothing was left of the very smallest consequence to be done at the pleasure and disposal of the person himself."

The same remark would be true regarding the Indians. Their religious life was as intense and all-pervading as that of the Israelites. It is yet noticed in full effect among tribes as widely separated, both by space and language, as the Zuñi and the Ojibwa, and their practices are astonishingly similar in essence and even in many details to some of those still prevailing among us.

Among the Hurons and Iroquois, there were religious rites for all occasions, among others for the birth of a child, for the first cutting of the hair of a child, for its naming and for its puberty, for the admission of a young man into the order of warriors and the promotion from warrior to chieftaincy; for the making of a mystery-man, for the putting of a new canoe into the water, for the breaking of ground for new fields, for the sowing and harvest, to fix the time for fishing, to decide upon a warlike expedition, for marriages, for the torturing of captives, for the cure of disease, for consulting magicians, invoking the daimons and lamenting the dead.

Shamans.—Among the Indians there was frequently an established and recognized priesthood, obtained by initiation into secret religious societies, corresponding in general authority with the Levites, although the latter were instituted in a different manner, perhaps imitated from the exclusive class of the priesthood in Egypt. The shamans in all tribes derived a large part of their support from fixed contributions or fees.

Adair describes a special ceremony for the admission or consecration of a priest among the southern tribes, as follows: "At the time of making the holy fire for the yearly atonement of sin, the Sagan clothes himself with a white ephod, which is a waistcoat without sleeves, and sits down on a white buckskin, on a white seat, and puts on it some white beads, and wears a new pair of white buckskin moccasins, made by himself, and never wears these moccasins at any other time."

Similar exclusive use by the High Priest of the garments used on the day of the atonement is mentioned in Leviticus.

In addition to the organized class mentioned, there were other

professional dealers in the supernatural who may be called conjurers, sorcerers or prophets, but were independent of and often antagonistic to the regular shamans. They arrived at recognition individually by personal skill in an exhibition of supernatural power, that is, they wrought miracles to prove themselves genuine.

At the time of the exodus there were, among all the Semitic tribes, sorcerers who possessed mysterious secrets and enjoyed some of the power of the elohim. They were paid to curse those whose ruin was desired. Balaam was the most distinguished sorcerer of that time.

One of the most frequent purposes for employing supernatural agency was to bring on rain in time of drought. The practitioner generally tried to delay his incantations as long as possible in hopes of a meteorologic change. Sometimes, on failure, he was killed, as he was supposed to be an enemy who possessed the power he professed but was unwilling to use it; and to prevent this dangerous ordeal in a dry season, he charged in advance certain crimes and "pollutions" of the people on account of which all his skill would be in vain. The more skilful rain-makers among the Sioux and the Mandans managed not to be among the beginners, but towards the last of the various contestants. The rain would surely come some time, and when it came the incantations ceased. The shaman who held the floor at the right time produced the rain.

Frequent reference to rain-making is found in the Old Testament, in which the prophets were the actors.

The mystery-men were consulted on all occasions as sources of truth, not only to explain dreams, but secrets of all kinds, to predict future successes in war or to tell the causes of sickness; to bring luck in the hunt or in fishing; to obtain stolen articles, and conversely, to produce ill luck and disease. Their processes, together with thaumaturgic exhibitions, included some empiric knowledge, and also tricks of sleight-of-hand and magnetic passes.

The Chahta had a peculiar mode of finding the cure for disease, by singing successively a number of songs, each one of which had reference to a peculiar herb or mode of treatment. The preference of the patient for any song indicated the remedy.

The Israelites believed that diseases as well as accidents without apparent cause, and other disasters, were the immediate acts of the Elohim or were caused by evil spirits; therefore they relied upon prophets, magicians or enchanters for exorcism. Hezekiah's

boil was cured by Isaiah. Benhadad, king of Syria, and Naaman, the Syrian, applied to the prophet Elisha. All the people resorted to their favorite mystery-men.

Even so late as the time of Josephus it was believed that Solomon had invented incantations by which diseases were cured, and some handed down by tradition were commonly used. Incense banished the Devil, which also could be done by the liver of a fish. Certain herbs and roots had the same power. Their medical practices might be recited, with slight change of language, as those of the Indians. The farther back any examination is made into savagery and barbarism the more prevalent faith-cure appears.

Witches.—The Indians were in constant dread of witches, wizards and evil spirits; but the activity of the good spirits was not so manifest. They however told Adair how they were warned by what he calls angels, of an ambuscade, by which warning they escaped. Bad spirits, or devils, were the tutelar gods of enemies, to be resisted by a friendly tutelar. The idea of a personal Satan was not found before the arrival of the missionaries.

Among the Indians witches were often indicated by the dreams of victims, and were often killed merely upon accusation, and it is interesting to notice, with relation to comparatively modern history, that the accused frequently confessed that they were sorcerers and declared that they could and did transform themselves into animals, become invisible and disseminate disease.

A sufficient reference to the Israelites in this connection is to quote the ordinance: "Thou shalt not suffer a witch to live." This injunction, in the higher civilization, is observed by destroying the idea that witches ever have lived or ever can live.

Dreams and divination.—The topics of inspiration by dreams and divination by oracles may be grouped together.

The Indians supposed that with, and sometimes without, a special fasting, and other devices to produce ecstasy, the spirits or daimons manifested themselves in dreams, and it was sometimes possible in these dreams for the soul to leave the body, even to visit the abode of departed spirits.

Among the Iroquoian tribes the suggestions made by dreams were implicitly followed, not only by the dreamer, but by those to whom he communicated his dreams. For instance, an Iroquois dreamed that his life depended upon his obtaining the wife of a friend, and though the friend and his wife were living happily, and parted

with great regret, the dreamer had his wish. The same tribe had a special feast which was called the "feast of dreams," and partook of the nature of Saturnalia. Every object demanded by the dreamers must be given to them, and in some instances they were unable to remember their dreams, and the special interposition of the mystery-men was invoked to state what their dreams were in fact and what was their significance.

Among the invaluable reports of the Jesuit missionaries, one in 1639 gives the general statement that the Indians consulted dreams for all their decisions, generally fasting in advance; that, in fact, the dream is the master of their lives; it is the god of the country and dictates their decisions, hunts, fishing, remedies, dances, games and songs.

The belief in revelations through dreams was universal, and the gift of explaining them was also a revelation. Their legends on this subjeet recall those about Joseph and Daniel. In addition may be quoted:

"In a dream, in the vision of the night, when deep sleep falleth upon men, in slumberings upon the bed.

"Then He openeth the ears of men and sealeth their instruction."

And in Deuteronomy a prophet is equivalent to a dreamer of dreams.

There were a variety of oracles among the Indians. Those most interesting to me are connected with pictography. Among many tribes, especially the Mandan, Hidatsa, Minnitari and Abnaki, after certain fasts and exercises various hieroglyphics deciding the questions which had been propounded appeared on rocks. They were deciphered by the shaman who had made them.

The apparatus by which Jahveh was consulted was the urim and thummin, a form of oracle described as connected with the ark. It ceased to be known in the fifth century before Christ and is now but vaguely understood. From the description and tradition it could, physically, have been worked by a custodian.

Severe fasts were probably the most common of the Indian religious practices, continued until they saw visions, sometimes for their own personal benefit, as deciding upon their names to be adopted from the advent of a guardian spirit, and sometimes for tribal advantage, the doctrine of all of them, as Father Lafiteau quaintly observes, being the same that prevailed among many people of his day, to lead the mind from gross and carnal obstructions

of the body. The real effect was to produce mental disorder. This ecstasy obtained by fasting was often accelerated by profuse sweating and the use of purgative or emetic drinks. Violent and prolonged exercise by dancing in a circle until the actors dropped in a swoon sometimes concluded the ceremonies.

The Israelite prophets were excited to inspiration by external means, such as dances and orgiastic proceedings resembling those of the dervishes and also of the Indian mystery-men. Music was a general accompaniment of the ecstasy. When they were about to prophesy, they became in a condition of frenzy, as if they were beside themselves. When Elisha sent one of the children of the prophets to anoint Jehu it was said of him: "Wherefore cometh this mad fellow?"

The Israelites, when they adored the golden calf sat down to eat and drink and then arose to dance and sing and the Indians used dance and song, or rather chant, in the same religious manner. The Hebrew festival (Hag) is closely connected with dancing in a circle.

Pollution and purification.—The subject of pollution and purification has been much and properly insisted upon as affording a striking parallel between the Israelites and the Indians. The Indians made special huts for the women, at certain periods, who were considered so unclean that nothing which they touched could be used. A Muskoki woman, after delivery of a child, was separated from her husband for three moons (eighty-four days). This may be compared with the Levitical law by which the mother of a female child was to be separated eighty days; of a male forty days; and Doctor Boudinot says that in some Indian tribes there was similar distinction between male and female children.

Among the southern Indians wounded persons having running sores were confined at a distance, as in the Levitical law, and kept strictly separate. An Israelite, dying in any house or tent made all who were in it, and all the furniture in it, polluted, and this pollution continued for seven days. All who touched a corpse or a grave were impure for the same time. Similarly, many of the Indians burned down the house where there had been a death, and all persons in it were polluted.

Many writers have asserted, as one of the excellencies of the Israelite customs, that the purification imposed upon those who had been engaged in a burial was a sanitary regulation, a measure ren-

dered expedient in a hot country. As no great proportion of the Israelites generally inhabited a country hot to the degree indicated, or had any conception of disease or the cause of death, this explanation is hardly sufficient. Much later the compilers might have gained some sanitary knowledge by which the old superstition was utilized. Its true explanation is from supernatural, not from natural concepts. It is probably connected with a point mentioned before; *i. e.*, the avoidance of corpses from the fear of the spirit of the dead and of the bad spirit which had caused the death, and the purificatory ceremony was for the demon, not for the disease. The neglect of sanitation is well illustrated among the Navajo, who are little affected by civilization. Upon the death of one of their members they block up the shelter containing the corpse and from fear of the spook or of the agent of death, or of both, not from fear of the corpse itself, never again visit it. Other tribes pile stones on the corpse which prevent its disturbance by beasts, but do not absorb the effluvium. Still others exposed the dead on scaffolds. To leave corpses to putrefy freely is certainly not a sanitary measure, yet it was a practice existing together with the mortuary rites before mentioned, though many of the tribes used earth burial and a few used cremation.

On a broad examination of the topic of "pollution," so styled by most writers, it seems to be best explained by our recent understanding of tabu.

Sacrifice.—Man once imagined superior forces who yet could be invoked and moved to and from any purpose. The divine world was produced in his own image and he treated its gods as he liked to be treated by his inferiors. He believed that the way to placate the forces surrounding him was to win them over as men are won over, by making presents to them. This clearly continued among the Israelites until the eighth century B. C., but it is to be regarded as a stage succeeding a former condition of zoölotry and totemism without notice of which its details cannot be understood.

Most peoples sacrificed to their divinities animals taken from their flocks, plants, fruits and herbs. People who had no domestic animals offered those taken in the hunt. The Indians offered the maize from their fields and the animals of the chase, and threw into the fire or water tobacco, or other herbs which they used in the place of tobacco. Sometimes these objects were hung up in the air above their huts. The northern Algonquins tied living dogs to

high rods and let them expire. In a similar manner other Indians stuck up a deer, especially a white deer, on poles. The plains tribes gave the same elevation to the head or skin of an albino buffalo on mounds, not having poles convenient. The spotless red heifer of the Israelites may be compared with the spotless white of the animals of the chase.

The southern Indians always threw a small piece of the fattest of the meat into the fire when eating or before they began to eat. They commonly pulled their newly-killed venison several times through the smoke of the fire, perhaps as a sacrifice and perhaps to consume the life spirit of the animal. They also burned a large piece and sometimes the whole carcass of the first buck they killed either in the winter or the summer hunt. The Muskoki burn a piece of every deer they kill.

The Israelites offered daily sacrifice in which a lamb (except the skin and entrails) was burned to ashes. In some of their sacrifices there was not only distinction between animals that were fit and unfit, but in the manner of treatment. Sometimes the victim was not to be touched, but should be entirely consumed by fire. In others the blood should be sprinkled around the altar and the fat and the entrails burned, the remainder of the body to be eaten by the priests. But it was a crime to eat flesh that had been offered in sacrifice to a false god.

The offering of the first fruits and therefore of the first born, to the divinity, was one of the oldest ideas of the Semites. Moloch and Jahveh were conceived as being the fire, devouring that which was offered to it, so to give food to the fire was to give to the god. In time, a substitute was suggested; the first born was replaced by an animal or a sum of money. This was called the "money of the lives."

Adair says that at the festival of the first fruits the southern Indians drank plentifully of the "cusseena" and other bitter liquids, to cleanse their bodies, after which they bathed in deep water, then went sanctified to the feast. Their annual expiation of sin was sometimes at the beginning of the first new moon in which their corn became full-eared, and sometimes at the accidental season of harvest. They cleansed their "temple" and every house in the village of every supposed polluting thing, carrying out the ashes from the hearths. They never ate nor handled any part of a new harvest till some part of it had been offered up; then they had a

long fast "till the rising of the second sun," taking their emetic drink. On the third day of the fast the holy fire was brought out and it was produced, not from any old fire, but by the rubbing of sticks. From this it was distributed to the people.

Lafiteau says that the first animal the young hunter kills he burns with fire as a sacrifice. Another festival was a kind of holocaust, where nothing of the victim was left, but must all be consumed, even to the bones, which were burned. There were also feasts of first fruits.

The Dakotas allowed no particle of the food at one of their religious feasts to be left uneaten. All bones were collected and thrown in the water that no dog might get them or women trample over them. It was common among many of the tribes that no bones of the beast eaten should be broken. There is no doubt that this is connected with zoölotry and was intended to prevent anger on the part of the ancestral or typical animal, the result of which would be the disappearance of the game. There were many other ceremonies of the same kind. When the Mandans had finished eating at any time they presented a bowlful of the food to a buffalo head, saying, "Eat this," evidently believing that by using the head well the living buffalo would still come and supply them with meat.

It is probable that what the authors have called the "day of atonement" or "expiation" was really a general wiping-out of offences or settlements of accounts between individuals and particularly between clans, after which there should be no reprisal. This is illustrated by a peculiar ceremony among the Iroquois, strongly resembling the scapegoat of the Israelites. A white dog, before being burned at the annual feast, was loaded with the confessions or repentings of the people, represented by strings of wampum. The statute of limitations then began to operate.

In the Jahvistic version, the Passover, an old festival held in the spring, was historically connected with the departure from Egypt. The ceremonies are too well known to require narration, but will readily be compared with those of the Indians.

Incense.—The use of the incense among Indians was the same as among Israelites, *i. e.*, to bring, and to please the spirit addressed. A genuine instance among the Iroquois was where tobacco was offered so late as 1882 and in archaic formal language still preserved, translated as follows:

Address to the fire. "Bless thy grandchildren, protect and strengthen them. By this tobacco we give thee a sweet-smelling sacrifice and ask thy care to keep us from sickness and famine."

Address to the thunder. "O grandfather! thou large voiced, enrich and bless thy grandchildren; cause it to rain so that the earth may produce food for us. We give this tobacco as thou hast kept us from all manner of monsters."

The Dakotas not only burned tobacco in their buffalo medicine to bring the herds, but used scented grass. Other tribes burned the leaves of the white cedar. These forms of incense were also used to entice the inimical spirits, the shaman being supposed to be able, when they had arrived in the form of a bear or some other animal, to kill them with his rattle. Some of the Indians believed that incense and sacrifices generally were only used for the spirits from whom they feared harm. They said it was not necessary to trouble themselves about the good spirits who were all right anyhow.

Fetiches.—Among many of the tribes of Indians there is a tribal totem (and often several clan totems) which, in later times becoming chiefly symbolic and emblematic, was once used in objective form for the most important religious purposes. Particularly, it was carried on extensive warlike expeditions. Adair, who calls it an "ark," describes it as made with pieces of wood, fastened together in the form of a square, to be carried on the back. It was never placed on the ground nor did the bearers sit on the earth when they carried it. In many other tribes it was a bag of skins and its contents varied, but generally were "blessed" or "sacred" fragments of wood, stone or bone. Among the Omaha it was a large shell, covered with various envelopes and was never wholly exposed to sight, which would occasion death or blindness.

A custodian was appointed every four years by the old men of the Blackfeet, to take charge of the sacred pipe, pipestem, mat and other implements which he alone could handle.

The ark of the Israelites was probably derived from the Egyptians who had a real ark, which was carried on the shoulders of the priests in processions. When the exodus began the Egyptian ark, for convenience, was changed into a chest fitted with staves for bearers. It became the standard of their warring and wandering life.

In addition to what has been called the ark or tribal fetich, the

practice that each Indian had his own mystery-bag is to be compared with the Israelite teraph which was a family or tutelary fetich independent of the national worship and frequently was the subject of later denunciation. It was probably made of carved wood, often carried on the person, but was generally held as a household god or domestic oracle. The teraphim markedly resembled the Roman penates.

This comparison is explanatory of the statement that neither the Israelites nor the Indians made idols. Its truth depends upon what is considered to be an idol. If the definition is limited to the human form, the assertion is true, because their religion was not anthropomorphic; but fetiches were certainly the objects of worship, the recrudescent forms of which, appearing even in civilization, have been amulets, lucky stones, pieces of wood and charms.

Sabbath.—It is not possible, in discussing the Israelites, to neglect the institution of the Sabbath. The four quarters of the moon made an obvious division of the month, and wherever the new moon and full moon are made religious occasions there comes a cycle of fourteen or fifteen days, of which the week of seven or eight days forms half. It is significant that in the older parts of the Hebrew Scriptures the new moon and the Sabbath are almost invariably mentioned together. Among the Israelites and perhaps among the Canaanites, from whose speech they borrowed, joy on the new moon became the type of religious festivity in general. There is an indication that in old times the feast of the new moon lasted two days, so that an approximation to regular recurrence of the subdivisions constituting the week was gained. The Babylonians and Assyrians had an institution dividing the month into four parts, by which, on the days assigned, labor was forbidden; but originally the Israelites' abstinence from labor was only incidental to their not working at the same time that they were feasting. While nomads, with only intermittent work, they had no occasion for a fixed day of rest.

The new moons were at least as important as the Sabbath until the seventh century before Christ. When the local sacrifices were abolished and the rites and feasts were limited to the central altar which practically could only be visited at rare intervals, the general festival of the new moon ceased. The Sabbath did not, but with the abolition of local sacrifices it became an institution of law

divorced from ritual. The connection between the week of seven days and the work of creation is now recognized as secondary. The original sketch of the decalogue probably did not contain any allusion to the creation, and it is even doubtful whether the original form of Genesis distributed creation over six days.

Subsequent history of the Sabbath shows a reflex action between religion and sociology. Religion prevailed against better arrangements for periods of rest. Sociology used religion to get what it could.

The Indians reached the first part only of the inception of the Sabbath in the ceremonies of the new moon, which were to them of great importance.

Circumcision.—This, generally regarded as a distinctive mark of the Israelites, is by no means peculiar to them, did not originate with them, and is found in so many parts of the world with such evidences of great antiquity as to contravene its attribution to them. Its origin is a subject of great dispute. As practised indiscriminately in infancy, it may perhaps, be a surgical blunder. It is certain that it was not at first among the Israelites a religious rite. The operation was not performed by the priesthood, but by a secular person of skill, without ceremony. It afterwards was regarded as an initiatory ceremony, and as such its parallels may be found all over the world, but as a special national distinction the declared object was not accomplished. Besides the Egyptians, Arabs and Persians, the coincidence with whom might be expected, many tribes of Africa, Central and South America, Madagascar and scores of islands of the sea show the same mark, and it has even been found in several of the North American tribes. The sole motive for alluding to this very comprehensive subject is to correct the popular belief that the custom is peculiar to the Israelites.

Parallel myths.—The Indian myths and legends supporting and explaining the religious opinions and practices before mentioned have a startling resemblance to those of the Israelites. It is not necessary to mention the deluge legends, which are common all over the world, at least in countries where inundations have occurred, and no more than general interest attaches to the mythical teacher, an inspired man or benevolent god in shape of man, who taught all that is known about hunting, fishing, the properties of plants, picture-writing and indeed every art, and founded institu-

tions and established religions, after which he generally disappeared, his actual death being seldom established. The legends of Michabo, Ioskeha, Hiawatha, Wasi and Manabosho will occur to all students as showing their analogue in Moses. A point of peculiar moment, however, is that the myths referred to are so strikingly identical in their minute details with those of the Israelites, even after all care has been taken to eliminate European influence and to assure their aboriginal antiquity.

An Ojibwa tradition tells the adventures of eight, ten and sometimes twelve brothers, the youngest of whom is the wisest and the most beloved of their father and especially favored by the high powers. He delivers his brothers from many difficulties, brought about by their folly and disobedience. Particularly, he supplies them with corn. A variant statue of Lot's wife, in stone instead of in salt, is still shown near the Mississippi River. The Chahta have an elaborate story of their migrations in which they were guided by a pole leaning in the direction to which they should go and remaining vertical where they should camp. A still closer resemblance to the guidance of the Israelites in the desert is in the migrations of the Tusayan where indication was made by the movement and the halting of a star. The Pai Utes were supported in a great march through the desert by water continually filling the magic cup until all were satisfied; and a similarly miraculous supply of food to starving exodists is reported.

Among the Ojibwa traditions there is a variant of the conception that man could not look upon the form of a divine being and live. In this case the divine beings were obliged to wear veils, and when one of them unintentionally let his eyes fall upon the form of a man the latter instantly fell dead as if struck by lightning.

The Medawe rite was granted the Ojibwa at the time of a great trouble through the intercession of Manabosho, their universal uncle, and rules of life were given them at the same time, which are represented in hieroglyphs on birch bark. They have a resemblance in motive to the Biblical legends and laws. At the time of a great pestilence, which was when the earth was new, the Ojibwa were saved by one of their number to whom a spirit, in the shape of a serpent, revealed a root which to this day they name the "snake-root," and the songs and rites of that medicine are incorporated in the Medawe.

Mr. Warren mentions that sometimes he translated to the old

Ojibwa men parts of Bible history, and their expression invariably was: "The book must be true, for our ancestors have told us similar stories generation after generation since the earth was new."

Last year a well informed representative of the Muskoki, in Washington, answered questions about the myths and legends of his people by the simple remark: "They are all in the Old Testament. Read them there without the trouble of taking them down from our people."

SOCIOLOGY.

The golden age of the Israelites, as recorded in compliance with tradition, was that ending with the Judges, when the people, without a monarchy, lived in a state nearest the ideal under a supposed theocracy, which also was a later idea. The exploits of Gideon, Jephtha and Samson are grand pictures of antiquity equal and similar to those in the Homeric poems. If the Indians could have written about their own past they would have portrayed a similar golden age, which, in fact, is mirrored in their traditions and myths. But from the absence of flocks and herds they were never in a true pastoral or nomadic state, and therefore never in the absolute patriarchal stage.

The Dakota, Comanche and some other tribes became adventitiously nomads only after the introduction of the horse by Europeans, afterwards supplemented by firearms. The large majority of the Indians never saw a horse until centuries after the Columbian discovery. So the pastoral stage, which among the Israelites accelerated their transition from savagery to barbarism, was not experienced by the Indians; and supposing that the two bodies of people were at one time equally advanced in culture, it might well have required three thousand years longer for the Indians to reach the stage in which they were discovered than for the Israelites to have arrived at the culture shown in the days of the Judges. At the time taken for proper comparison, both peoples were living under the clan or totemic system.

A clan is a body of kindred in which kinship is established by laws now long disused, and so strange to our present ideas as to be comprehended with difficulty. Some of the more salient features of the system appear in the division of the people into tribes interpermeated by the clans, with special rules of government, adoption, protection, punishment, property and marriage.

The totemic stage was first intelligently noticed, and yet has its typical representation, among the aborigines of America and Australia. Among the latter it is called kobong. An animal or a plant, or sometimes a heavenly body is connected with all persons of a certain stock, who believe that they are the descendants of it as their totem, their protecting daimon, whose name they bear. The line of descent is normally from the mother. When a clan becomes dominant its totem daimon may come to command the worship of all the clans or tribes in the group, the other gods becoming subordinate.

The clan system lately found in actual force in two large geographic divisions of the world has preserved a clue to the mouldered maze of man's early institutions. What is known of the clans, tribes and league of the Iroquois explains what, until recently, was mystical about the tribes of Israel.

Each clan or tribe had a badge or totem from which it was named, generally an animal, as eagle, panther, buffalo, bear, deer, raccoon, tortoise, a snake or a fish, but sometimes one of the winds and other noticeable phenomena.

The Israelites had their standards. It is not probable that the blessings of Jacob and of Moses, referring to them, were merely metaphoric. In the former, Judah is named as a lion, Issachar as an ass, Dan as a serpent, Naphtali as a hind, Benjamin as a wolf, Joseph as a bough. In Moses' blessing four of such names occur—Ephraim as a bullock, Manasseh as a bison, Gad as a lion, and Dan as a lion's whelp. The inference is strong that these were the leading totems in the several tribes, and the slight disagreements in the lists may be accounted for by the fact that the head clan in Dan had changed in the interval.

David seems to have belonged to the serpent stock. The most prominent among his ancestors bore a serpent's name. Some circumstances in his life show his connection with a serpent totem.

Critics have doubted whether Moses was so opposed to idolatry as asserted later, for a brazen serpent, perhaps an ancient idol of Jahveh, said to have been set up by him, was in existence until the reign of Hezekiah who broke it into pieces. It is true that it might have been an idol of Jahveh, perhaps worshipped as a teraph, but it might have been simply a totem. The erection of the brazen serpent by Moses in the wilderness may be more consistently explained by totemism than by idolatry in its usual sense.

Government.—The powers of Israelite rulers were conferred on emergencies and were intended to be of short duration, but while they lasted were dictatorial. The Judges were despots without a standing army or an organized government. Their selection was due neither to descent, to suffrage, to feudal investiture, nor to violence, but was from the man's superiority, his ascendancy, strength and courage. It was rare for a man thus invested with power to be deprived of it before his death.

The alliance of the tribes was loose. They seldom hesitated to war upon one another. Even after nationality had been initiated the genius of David and the magnificence of Solomon could not permanently weld them together, and doubtless they would have temporarily fallen back into the incoherent state from which the Indians never emerged but for the late and conservative establishment of Jahvism which the Indians did not have.

The characteristics of the Israelite and of the Indian, as of the Homeric Achæans, were predatory—the tribe and its clans, with their alliances, against the rest of the world.

In the investigation of totemism among the Israelites it is important to compare its continued existence in Arabia because the state of society there remains more primitive than it was in the land of Israel when the Old Testament was written.

A large number of tribes having animal names are still found among the Arabs, for instance, Lion, Wolf, Ibex, She-fox, Dog, Bull, Ass, Hyena and Lizard. The origin of all these names is referred by the people to an ancestor who bore the tribal or gentile name. Also the animal names given in the tribal genealogies are often found belonging to sub-tribes, the same animal sometimes occurring in subdivisions of different tribes, these particulars corresponding with the Indian system.

The tribes of the southern and eastern parts of Canaan had affinities both to Israel and to the Arabs. The Arab princes of Midian were the Raven and the Wolf—heads of tribes of the same names. More than one-third of the Horites, the descendants of Seir the he-goat, bear animal names; so do the clans of the Edomites. It is disputed what the real name of Moses' father-in-law was; but he had some connection with the Kenites. The list in Genesis XXXVI, is a count of tribal or local divisions and not a literal genealogy. It is full of animal names, and the antelope stock was divided over the nation in a way only to be explained on the totemic and not

a genealogic system. The same names appearing as totem tribes in Arabia, reach through Edom, Midian and Moab into Canaan where they show local distribution, only intelligible on the assumption that the totem system prevailed there also when the first books of the Old Testament were written.

Professor Robertson Smith gives a select list of about thirty persons and towns bearing names derived from animals and plants. Dr. J. Jacobs has expanded this into one hundred and sixty such names, though their importance is considered by him to be lessened by the frequency of such names in England, forgetting, apparently, that the clan system also existed among the ancestors of the English people.

The tribe of Judah received the powerful accession of the Dog tribe, the Calebites, among whom there were many animal names.

With such facts, and the knowledge that the early Israelites freely intermarried with the surrounding nations, it is to be supposed that the totemic system of those neighbors should appear in all Israel, as was obviously the case in Judah.

The 26th chapter of Numbers gives the clans of the tribes. Altogether seventy-two clans are mentioned, and of these at least ten occur in two tribes, striking among whom are the Arodites or Wild Ass clan, found both in Gad and in Benjamin. Other clans also have animal names; the Shillimites or Fox clan, of Naphtali; the Shuhamites or Serpent clan, of Benjamin; the Bachrites, or Camel clan, of Ephraim and Benjamin; the Elonites, or Oak clan, of Zebulon; the Tolaites, or Worm clan, of Issachar; and the Arelets, or Lion clan, of Gad.

A special suggestion comes from the tribe of Simeon. In the blessing of Jacob, Simeon is coupled with Levi as a tribe scattered in Israel. There were Simeonites in the south of Judah, but they do not appear there as an independent local tribe. According to Genesis XLIX, there must have been branches of the tribe elsewhere. It would seem that Simeon remained as a divided stock, having representatives through the female line in the different local groups. When the old system was displaced, Simeon lost importance and ultimately dropped from the list of tribes. The name of the tribe was lost but not the people, as has been noticed in careful statistical examination of the Indians.

In the stage of barbarism man belongs not to himself, but to his

clan and tribe. In civilization responsibility is personal, and there can be no crime without a criminal intent. This was not so in the clan system, so the rules of obedience, punishment and protection were peculiar.

Clan Punishment.—The Indian punishments known were death or expulsion from the tribe, the latter, from the unprotected state of the offender, being tantamount to death. The code consisted in the application of the *lex talionis*. The vengeance of blood for homicide was exacted as a clan duty. This was executed by the clan of the person killed, generally by the nearest of clan kinship, and it was required even if the death were by accident, unless condoned by payment. Among the Israelites, as among the Indians, the duty of blood revenge appears to have lain on the kin by the mother's side.

Sanctuary.—The fact that no crimes could be individual, but were against a clan by a member of a clan, rendered it necessary to have some special provision to restrict vengeance; so the right of sanctuary, which appeared later as a prerogative of religion, was in its origin sociologic.

The avenger of blood among the Indians generally had the right to slay the criminal if found within a specified time, such as two days, after the act; but if he should escape that long the avenger could no longer pursue and was himself liable if he should persevere. The clan at that stage interfered, and there were among some tribes localities (called by Adair the "Cities of Refuge") designated, in which the criminal should be safe from minor offences until the general wiping-out of vengeance at the next annual festival. Compare Numbers xxxv, 12: "And they shall be with you cities of refuge from the avenger, that the man-slayer die not until he stand before the congregation in judgment."

The functions of the avenger of blood are only referred to in the Pentateuch, but were well known in ordinary cases. The law treats of the exceptional circumstances of an accidental homicide. There is a trace, in Deuteronomy xxiii, of the general communal sanctuary in Israel. It enacts that any town or village shall be an asylum for an escaped slave. In Exodus xxi, the altar (presumably any one of the numerous village altars) is mentioned as a refuge. In the cities of refuge the sanctuary was used only for the mitigation of the revenge of blood, as Israel retained the old *lex talionis*.

A mode of bringing to notice the barbarian stage of the Israel-

ites at the time mentioned, is to translate into English familiar personal names from the Old Testament, such as the Dog, the Dove, the Hyena, the Lion's Whelp, the Strong Ass, the Adder, the Running Hind. This brings into immediate connection the English translation of Indian names, such as Big Bear, White Buffalo, Wolf, Red Cloud, Black Hawk, Fox, Crow and Turtle. It is possible that in addition to gentile derivations (for the Israelites in that sense were Gentiles), a reason for the adoption of such names was that they could be represented objectively, as is certainly the case among the Indians, who possess very few names that cannot be represented in pictographs; and the very large topic of tattooing is connected with this device antecedent to writing. The compilers of the Old Testament probably desired to break down a former practice as is shown in Leviticus XIX, 28: "Ye shall not print any marks upon you." And there are other similar indications.

Adoption.—The early history after the exodus shows many cases of adoption from among the neighboring tribes, in which the captive or the stranger adopted became a member of one of the clans for the same reason as among the Indians, as otherwise he could have no status.

Caleb is first known as the son of Jephunneh, the Kenezite. Next he appears as a chief of the tribe of Judah; finally, in the book of Chronicles, his foreign descent is lost. He becomes Caleb, the son of Hezron, the son of Judah. This is an instance of adoption and is not contradictory, as Caleb could have no place in the tribe except by adoption. He is first described in accordance with the actual facts of his descent, but when adopted with his family and followers forming probably a sub-clan, he would be called by the name of the family that adopted him.

The whole population of the country which, according to Deuteronomy, was to have been exterminated, slowly became amalgamated with the invaders. In this way alone their rapid increase can be accounted for.

Not until the late prophetic influence was the doctrine established that no quarter should be shown to the enemy and no alliance made with the Goim, a word meaning the "nations", with the implication of "heathen", the use of which dates from the ninth century B. C. It is gratifying to believe that the stories of the wholesale extermination and cruel outrages injected into the historical narrative were afterthoughts intended to be examples for

the future and that they never occurred in fact. Otherwise the brutality of the Israelites to the conquered would have been more horrible than that of the Indians among whom captivity was tempered by adoption.

An interesting custom of the Indians connected both with the rite of sanctuary and that of adoption is that when captives had run through what was called by English writers "the gauntlet" to a post near the council house, they were for the time free from further molestation. It is possible that in the northeastern tribes this was in the nature of an ordeal to discover whether or not the captive was vigorous and brave enough to be adopted into the tribe; but among other tribes it appears in a different shape. Any enemy, whether or not a captive, could secure immunity from present danger if he could reach a similar post, or if there were no post, the hut of the chief. A similar custom existed among the Arikara who had a special pipe in a "bird-box". If a criminal or enemy succeeded in smoking the pipe contained in the box he could not be hurt. This corresponds with the safety found in laying hold of the horns of the altar.

Land.—In the earlier history of the Israelites there could be no individual property in land—it belonged to the clan as it did among the Indians. When arriving at sedentary and national life an expedient was invented to compromise the permanent possession of land by the clan, with individual rights of occupancy, which would allow of a proper stimulus for improvements. This was done by the institution of the Sabbatical year, or the year of Jubilee. The Indians, not having reached the sedentary stage (except in rare instances), were not obliged to invent that device. The similarity remains, therefore, that no man could acquire an absolute property in land. The title was not in him but in his clan.

Forbidden food.—The Indians long observed a prohibition of eating any part of the animal connected with their totem, and of course also of killing it. For instance, most of the southern Indians abstained from killing the wolf; the Navajo do not kill bears, the Osages never killed the beaver until the skins became valuable for sale. Afterwards some of the animals previously held sacred were killed, but apologies were made to them at the time, and in almost all cases a particular ceremony was observed with regard to the reservation of certain parts of those animals from food, on the principle of synecdoche, considering the part to rep-

resent the whole, the temptation of using the food being too great to permit entire abstinence. The Cheroki reserved the tongue of the deer and bear from food, which they cut out and cast into the fire. An instance, reported this year as still existing among the Ojibwa, is in point, where there is a formal reservation, yet by a subdivision among the same clan, an arrangement is made in which subclans may among them eat the whole animal. A bear is killed; the head and paws are eaten by those who are one branch of the bear totem, and the remainder is reserved for others. There is a a common differentiation in which some persons can eat the ham and not the shoulder and others the shoulder and not the ham of certain animals.

The Egyptians did not allow the eating of animals that bore wool. This is attributed to the sacred character of the sphinx, and has other religious connections. It is supposed by some writers that the legislation of Moses with reference to forbidden food, was to antagonize social union with the Egyptians by permitting to the Israelites articles not used by the Egyptians, and *vice versâ*. It is true that some forbidden food of the one nation was allowed to the other, but the abstinence of both from swine is not consistent with the hypothesis.

The survival of totemism may be inferred from the lists of forbidden food in Leviticus XI, and Deuteronomy XIV. It would appear that about the time of the exodus the Israelites were organized on the basis of families or clans tracing through female lines, and named Hezir (swine), Achbor (mouse), Aiah (kite), Arod (wild ass), Shaphan (coney), and so on. Each of the clans refrained from eating the totem animal or only ate it sacramentally. As the totem organization declined, the origin of the abstinence would be lost, but the custom lasted, and when the legislation was codified it was incorporated in the code. The hypothesis would explain certain anomalies in the list; *e. g.*, coney, or rock badger, for which no other deserving attention has been given. The division into clean and unclean food by the two tests of cloven foot and rumination was a later induction from the animals regarded as tabu. This is confirmed by the want of any systematization in the list of birds given in Leviticus.

It would be expected that animal names were connected with the animal worship before mentioned, and there is some evidence that men, bearing a common animal stock name, though in different

tribes or nations, recognized a unity of stock. Our most definite information on the subject is derived from Ezekiel, chapter VIII, where there seems to be an account in which the head of each house acted as priest, and the family or clan images, which are the objects of idolatry, are those of "unclean" reptiles or quadrupeds, *i. e.*, those which are prohibited from use as food. It is true that the argument of Professor Smith on this subject is controverted by Doctor Jacobs, but only as to the survival, not as to the early existence of the cult.

No one has yet given a satisfactory theory of the Israelite division between clean and unclean animals, apart from the explanation afforded by the totemic system. No rational motive can be assigned for the avoidance of certain animals, in themselves hygenically good. The explanation that swine's flesh was liable to bring disease, and therefore was prohibited for a sanitary reason only, covers but a small part of the subject and is not in itself satisfactory. The meat of the hog is, in fact, as wholesome in Syria as it is in Cincinnati, and the medical conception of trichinosis had certainly not arisen in the times under consideration. The avoidance of all meat, indeed of all food, for purposes of fasting and producing ecstasy, is in a different category and has already been mentioned.

Marriage.—The laws of marriage in the stage of barbarism are intricate, but attention may be directed to a few points which strongly distinguish its features from those in civilization. Its most general characteristic is that it was strictly by legal appointment. The levirate, named from the word levir, a husband's brother, is in brief, the practice by which it is the combined right and duty of a brother—often the eldest surviving brother—to marry the widow of his deceased brother. Prof. E. B. Tylor reports that this practice appears among one hundred and twenty peoples; *i. e.*, in about one in three of the distinct peoples of the world. It was almost universal among the Indians, sometimes with additional duties and privileges. A widow, as a rule, could not marry any one but her deceased husband's brother except on his refusal or after a long time of mourning.

In several tribes the marrying of an elder sister gave rights over all the others; and sometimes the son-in-law, especially when he married the eldest daughter, became entitled to all the property of her father, and also the younger sisters of his wife if he chose.

Other men could not take them until after his refusal. This right to all the unmarried younger sisters sometimes continued after the death of the first wife. Not unfrequently a man married a widow and her daughters at once.

Among the Israelites it was common to have several wives of equal status, who often were sisters. A widow had a right to appeal to her brother-in-law, or some member of her husband's family, for a second marriage, and an evasion of the duty was a gross offence. Deuteronomy xxv shows the degrading terms of the formality by which the brother-in-law was freed from the obligations of marriage and the widow allowed to marry another man. Judah admitted that Tamar's conduct was perfectly correct. It was but a legitimate extension of the levirate law.

There is the clear statement in Leviticus that the Egyptians and the Canaanites formed such marriages as with them were connected with the totemic system but by the Israelite law were made incestuous. The laws of incest given in Leviticus are probably later than the code of Deuteronomy where the prohibition is directed against marriage with a man's father's wife. This precept denounces the practice in Arabia by which the son inherited his father's wife as his property.

In the framework of the Deuteronomic code there were three prohibitions: father's wife, sister, and wife's mother. To these offences Ezekiel adds marriage with a daughter-in-law. All those forms of quasi-incest were, according to the prophets, practised in Jerusalem; and the history seems to show that all were once recognized customs. The taking of a father's wife was not wholly obsolete in the time of David.

As regards the Israelite descent in the female line, it may be noticed that the children of Nahor by Milcah were distinguished from his children by his other wives. Rebekah's descent is practically valued as a descent from Milkah, and the family or clan connections is traced entirely through Milkah and Sarah. Moses' father married his father's sister; Nahor married his brother's daughter; Abraham married Sarah, the daughter of his father but not the the daughter of his mother.

A passage in Judges relates to exogamy, recording that Ibzan had thirty sons and also thirty daughters whom he sent abroad, and took thirty daughters from abroad for his sons. Exogamy, however, could not be kept up when the Israelites became mainly an

agricultural people, and in the times of the kings only survivals of it remained.

Mr. Fenton, in his acute remarks upon the story of Lot's daughters, has not exhausted the subject. It was not only the fact that according to the clan system it was proper for Lot to marry his daughters, but under the circumstances it was obligatory upon him to do so. The logical propriety of the marriage of a father to his daughters, on the ground that they did not belong to the same clan, is clear, and the practice exists to-day among a number of the tribes of Indians not much affected by European influence. A father was not of kin to his own children. They belonged to the mother's clan, and not to his. An interesting example of this clan law is narrated by Dr. George M. Dawson as still existing among tribes of British Columbia, where a rich Indian would have nothing to do with the search for his aged father who was lost and starving in the mountains. Not counting his father as a relative, he said, "Let his people go in search of him." Yet that son was regarded as a particularly good Indian.

There are other instances where the son would fight against the father to the death. Such cases would occur where a son married, necessarily, a woman of another clan, and went to live with her people, and when there was warfare between her clan and that of his father, he was by association expected to fight against the latter, there being no reason why he should not.

It is, however, true that, in a large number of tribes of Indians, the marriage of father and daughter has been, during the time of European examination, very rare. It may be suggested as a reason that a gradual change has occurred from the mother-right to the father-right, in which the attitude is reversed; but practically the fact that, either the father or mother, by treating the daughter as an object of value or merchandise, could secure presents from the suitor, would have tended to break down this part of the clan marriage system before any other, and, the custom ceasing, the practice became wrong. So it is true to-day among Indians, as it was in a much more marked degree at the time of the compilation of the existing version of the Old Testament, that the marriage of a father and daughter is reprobated. In this connection it is interesting to notice that the Navajo have a myth, undoubtedly native, that in the old time one of their race took his daughter to wife

and their offspring became the ancestor of the Utes, the hereditary enemies of the Navajo. This is a parallel with the stigma inflicted upon the Moabites and Ammonites who were the descendants of Lot and the enemies of the Israelites who wrote the history but yet were recognized by the latter as of the same stock.

The part of the story of Lot which tends strongly to show its later manipulation, is that the authors of the version, having at that time the idea of a horrible incest, explained that the good man, specially so designated by tradition, was guilty of it only because he was unconscious through intoxication. They were obliged in accordance with one tradition, to make him the ancestor of Moab and Ammon; from another tradition they had him left without any sons and no wife, the two daughters being all of his family who survived the destruction of Sodom. They used their materials, therefore, with the excuse of intoxication, but there was no occasion for such excuse. In the age to which the tradition related, the transaction was perfectly proper, does not involve sexual passion, and was required by law to keep up the stock, but the clan rules had been forgotten when the book of Genesis was written.

In the stage of barbarism the marriage of brother and sister was common all over the world. Where polygamy existed, as was the case among the Israelites, and probably among all the Indians, a man could not, according to the rules of the gentile system marry into his own clan. If he took several wives it is probable that they would sometimes be of different clans not only from his own, but from one another. In such cases the child of the wife of clan A was not of the same clan as the child of the wife of clan B, and they could marry. The marriage of uterine brothers and sisters was not consistent with the clan rules.

Writers on the subject of the clan system have extolled it as being profound with physiological insight to prevent inbreeding; but the best and latest physiologists doubt that inbreeding is bad unless there is a taint of blood which should prohibit the marriage of either party to any one, and a true understanding of the clan system would have shown that as it certainly permitted marriage between a man and his half-sister, and with his aunt, his father's sister, if not the more violent case of father and daughter, it did not accomplish the object lauded.

The late prohibition of a man's marriage to his deceased wife's

sister cannot be maintained on any principle of physiology or sociology. It is a blunder that perhaps arose in the transition stage from the matriarchate to the patriarchate system.

CONCLUSIONS.

It has often been asserted that the Semites, and specially that branch of them lately styled the Syro-Aramæans, were specially adapted to a spiritual religion; that monotheism was in their racial constitution; that whether through revelation or because they were well adapted to receive such revelation, their idiosyncrasy directly led them to spiritual ideas, which to modern minds means monotheism. This was not the record of the historical books of the Old Testament, even after their manipulation. The prophets of Israel declared the exact contrary; they denounced their own people as rejecting spiritual proof and as not deserving the favor of Jahveh. This declaration is confirmed. The beliefs and practices of the Israelites were substantially the same as those of other bodies of people in the same stage.

The Israelites were not a "peculiar" people. There is, racially, no peculiar people in the sense intended. Mankind is homogeneous in nature though placed in differing and ever advancing grades of culture. What has been called blood in a racial sense may be likened unto the water of the earth;—as it comes from the clouds it is chemically the same, and it is subjected, wherever it is, to the same laws. The early course of a rill may be turned by a pebble, and from the elevations and depressions met it may become a lake or a river, or a stagnant marsh. From the character of soil encountered it may be clear or muddy, alkaline, chalybeate or sulphurous. In one sense, which belongs to modern and not to ancient history, the Jews are a peculiar people, from the fact that for many centuries, until lately, they proclaimed themselves to be such and observed religiously the doctrine about the Goim, and therefore did not intermarry with other peoples; but this also has been from the fact that persecution made them pariahs and the other peoples would not intermarry with them. The so-styled purity of their race has been kept up by isolation during the recent centuries, but the assumption of great purity in the stock at the Christian era is not tenable, and now that their prejudices and those against them are dissolving, it is probable that what has been improperly called the Jewish race will disappear by absorption in precisely the same man-

ner that the Indians are now disappearing. To renew the simile, they both will be lost in the homogeneous ocean which all mankind seems destined to swell.

I do not enter upon the controversy respecting the races of mankind except to confess, as the sum of my own studies on the subject, that all attempts at the classification of races have failed. The best generalization may be taken from the address of Professor Flower to the Section of anthropology of the British Association for the Advancement of Science: "I am compelled to use the word race vaguely for any considerable group of men who resemble each other in certain common characters transmitted from generation to generation." The most useful mode for the examination now of peoples by anthropologists is not by attempts at racial divisions, but by the determination of their several planes of culture with the recognition of specific environments. Admission of this fact is practical. The most sensible remarks ever made by missionaries were those of the Rev. Messrs. Lee and Frost who, after ten years in Oregon of what has been considered successful work, announced their abandonment of their former belief that if the heathen were converted to Christianity civilization followed of course. They confessed that civilization must begin before Christianity could even be understood. Acute travellers throughout the world have perceived the same fact, and it is not a too violent simile to say that Christianity, belonging to the plane of civilization and to that only, sits on a savage or barbarian as a bishop's mitre would on a naked Hottentot.

Moses did not change the Israelites from their barbarian condition. It was not possible. As regards the culture strata we may take a lesson from geology. Coal is not found in the Silurian formation, therefore wise miners do not look there for coal. The higher mammals are not found earlier than the Cenozoic, though their precursors are in the Jurassic. Let us look in the savage stage as if it were Jurassic to understand and trace what we may afterwards find in the barbarian or Cenozoic, and developed later in the present epoch; but to search for the complete ideas of civilization in the period of barbarism would be as sensible as to dig for manuscripts among the workshops of flint arrowheads.

There is a Rabbinical legend that Lot first argued the existence of one god ruling the universe, from the irregular phenomena observed on land and sea and among the heavenly bodies. "If these

had power of their own," he said, "they would have had regular motions, but as they had no regularity they were subservient to the occasional exercise of a higher will." With greater scientific knowledge these supposed irregular motions are now embraced within laws considered to be permanent, if not immutable; but the existence of such tremendous laws gives a higher conception of their maker. Their suspension or violation is not in accordance with human reason, and mere suggestion of such variations clouds the glory of divinity.

The doctrine attributed to Lot is instructive, because its conception of nature permeated all the early philosophy. We now define a miracle specifically as a deviation from the laws of nature. But to those for whom nature had no laws, the prime definition as "the wonderful" was alone correct. A supernatural being could, and was expected to, do anything whatever in accordance with his arbitrary will, and men who were inspired or empowered by the supernatural were also expected, in fact required, to work wonders. It would hardly be a paradox to assert that the supernatural was alone natural and that in the explanation of phenomena only the irregular was regular.

The order of the evolution of revelation, as may be appreciated by every student regarding all revelations but that one which he credits, is that some practice existed early for which a natural explanation may be made. This practice became a formal custom which, after a time, was considered to be obligatory under the vague but compelling idea that it is "bad luck" not to observe it. Bad luck is necessarily connected with the supernatural, therefore the custom or the series of customs became a religion, and that was always explained at a later time by a myth which was not necessarily an explanation made by imposture or fraud, but grew from the curiosity of men and their hurry to account for everything. All such myths are declared to be obtained, through revelation, from a power higher than man. The result is, therefore, that revelation, which is the last step in the evolution of religion, is enounced by antedating, to be the first step. When revelation is once admitted, man's mind clings to it as a refuge from doubt which always must attend the results of reasoning on subjects not admitting of demonstration. Such clinging becomes fanatical with most men because they dread as the greatest injury to be cast into the hands of the Giant Doubting who for them is but another name for Giant Despair.

There is also a sentiment involved that the old thought, that of the ancestors, is always the best. This is incorrect unless on the theory that all knowledge comes from revelation. The continuance of the old is bad because it is old and is maintained through superstition in the true etymological sense of the word. Some advocates of the old reject all new thoughts, but the more intelligent attempt to force a reconciliation. What they believe now must be right. What they are not accustomed to is shocking, therefore is wrong. So the old, which was always right, must be distorted to contain in it the new which also is right, and what there is in the old that cannot be managed otherwise must be explained away.

An apparent exception to the unfitness of old direct teachings is where there has been a general degradation in culture after which a return to the results of the former and forgotten culture is most desirable. This is illustrated in the revival of learning after the dark ages in Europe when the classic writings as discovered and studied brought new illumination to the world. But this was a simple readjustment of sequence after a hiatus. The advance of development, not chronology, makes the proper criterion. The archaic is that which is nearest the beginning of human life. We have the history of the Israelites for forty centuries; we have that of the Indians for little more than three centuries; yet though the Israelites advanced in recorded times beyond the plane of the Indians, who shall say which of these was the older people?

He would be both silly and malicious who should impugn my treatment of the present subject as a direct or covert attack upon the books of the Old Testament. On the contrary, I regard that noble work as the most important anthropologic record possessed by man, richly repaying such study and comparison as all valuable records demand. I gladly accept it as a genuine account, and believe that though it has been colored by time and by the work of man, it never was invented, and is not to be treated as a literary or religious fabrication. It is asserted that some persons occupied in science fear or pretend to scorn the Bible. I do neither. I admire it, and study it, and gain much from it; but no intelligent persons take as of the same authority all its versions or indeed all the contents of the books arbitrarily styled canonical on the very names and numbers of which churches and sects dispute.

The Hexateuch contains the same intrinsic evidence of truth as was obvious to the Ojibwa, before mentioned, who said that the

work was true because they and their fathers "had heard the same stories since the world was new." To those who can read it understandingly it is a true story of a plane of culture. But when we find that distinct revelations have been and are claimed by all the tribes of men in that plane of culture we are forced to recall the words of the sage who gave as the reason for his disbelief in ghosts that he had seen too many of them.

"Now as to myself I have so described these matters as I have found them and read them, but if any one is inclined to another opinion about them, let him enjoy his different sentiments without any blame from me."

PAPERS READ.

SOME PRINCIPLES OF EVIDENCE RELATING TO THE ANTIQUITY OF MAN. By W J McGEE, U. S. Geological Survey, Washington, D. C.

[ABSTRACT.]

THE principles of evidence relating to the antiquity of man may be summarized in a series of propositions which it is the object of the paper to discuss. The primary propositions are: 1. It is a fair presumption that any artificial object found on the surface is modern; 2. It is a fair presumption that any stone object of doubtful origin is natural; 3. It is a fair presumption that any unusual object found within, or apparently within, an unconsolidated deposit is an adventitious inclusion; 4. It is a fair presumption that an isolated association is adventitious; 5. It is a fair presumption that an incongruous association is adventitious. These presumptions may be outweighed by direct or collateral evidence, and indeed have been so outweighed in all of those cases which prove a high antiquity for human kind; but in weighing such direct or collateral evidence, certain additional and more general principles must be recognized. The more general propositions are: 1. In inductive science the value of evidence varies with its volume, its consistency, and its cumulative character; 2. In inductive science the sufficiency of a given body of evidence varies inversely with the importance of the conclusion to which it leads; 3. In inductive science every conclusion is tentative; 4. In exact knowledge the sufficiency of evidence and the validity of conclusions vary inversely with the exactitude of the branch of science affected.

POINTS CONCERNING THE LITTLE FALLS QUARTZES. By Miss FRANC C. BABBITT, of Coldwater, Mich.

[ABSTRACT.]

THE Little Falls quartzes to be considered in the present paper are strictly limited to the implements and chips found by the writer, in 1879, upon the east shore of the Mississippi river, at Little Falls, Morrison county, central Minnesota. These quartzes were taken from an implement-bearing

stratum a few inches in thickness wherever examined, lying about fifteen feet below the actual surface; and they are not to be confounded with the quartz pieces distributed through the upper soil in the immediate vicinity, described by the state geologist, Prof. N. H. Winchell, in his sixth annual report.

A point fundamental to any fruitful study at large of these objects is the essential one: Are they genuine palæoliths? The inquiry formulates a dual problem in origins—origin as to agency, and origin as to time. Leaving out of the account the minor differentiations nascent in American palæolithics, the general question involves, in the present case, these two: Were the Little Falls quartzes shaped by man? Were they produced prior to the close of the last glacial epoch? The two inquiries naturally address themselves to two quite distinct departments of science, namely, archæology and geology.

In accordance with this view of the matter, and at the suggestion of the state geologist of Minnesota, the quartzes indicated were early submitted to authorities upon the primal productions of the human race, for an ultimate decision as to their artificial character. The subject of their relative antiquity was meantime referred to specialists in the quaternary geology of the region. Parcels of specimens have found their way at different times to various scientific institutions, and have likewise been supplied, for purposes of study and comparison, to distinguished archæological experts, as to Dr. Charles Rau, to Dr. C. C. Abbott, and to Professors Haynes, Putnam and Mason.[1]

With the exception of Dr. Rau, deceased, whose final conclusions were not communicated to me, the authorities named concur, as I have been assured, in declaring these quartzes to be the unmistakable product of intention; either as chips struck off in the process of manufacture, or as imperfect or finished implements. Certain of the latter have been identified with well-known types, their assimilation to which is regarded as essential and not fortuitous, and as indicating that the widely scattered palæoliths of this continent and the other had a common *raison d'etre*. Let it be understood, therefore, that the artificial character of the specimens in hand is not established upon my own personal *ipse dixit*, nor that of any other individual, but upon the unanimous verdict of qualified scientists of international repute. As these authorities are equipped with special facilities for comparison, and have an intimate acquaintance with objects of the class discussed, there appears to be no sound reason for distrusting their matured opinion. Professor Putnam has, at different times, brought typical specimens of these objects before the Boston Society of Natural History for general examination and comparison with other palæolithic

[1] Dr. Rau turned over to the Smithsonian Institute the specimens forwarded for his inspection; Dr. Abbott placed those in his keeping in the Peabody Museum of American Archæology. The objects exhibited before section H, of the A. A. A. S. at its Minneapolis and Philadelphia meetings of 1883 and 1884, together with others submitted to examination by Professor Haynes, have been consigned to the same institution.

implements, American and foreign. In the proceedings of this society for the present year, pages 164–5, he presents figures of Little Falls quartzes, of which he says:—" Others of these before you are identical in shape as well as material with the specimens obtained by Dr. Abbott from the Trenton gravel, and certainly their artificial character will not be questioned." Professor Haynes, in the chapter on Prehistoric Archæology of North America, in Vol. I of Winsor's Narrative and Critical History of America, expresses a like opinion, formed upon the study of numerous specimens that have been submitted to him, but not the same as those upon which Professor Putnam has based his conclusions.

THE QUARTZ STRATUM AN ARTIFICIAL FORMATION.

Prior to the actual test of the Little Falls quartzes by comparison with others, certain peculiarities of their accumulation led to the conjecture that they had been posed in their present bed through design, and that a portion of them had been used by man, whether they had received shape at his hand, or not. The quartz stratum as a whole appeared to be an artificial formation, quite irrespective of the particular origin of included individual specimens. This was shown by its mode of deposit, its general composition, and the assorted condition of its contents.

First, the quartzes seemed to have been deposited originally upon dry land, and by other agency than water. This was indicated by peculiarities in their occurrence. Thus they were not distributed promiscuously through the modified drift, in the manner of those reported by Professor Winchell as scattered through the soil where "large trees tear it up." They were, on the contrary, compacted in a thin, nearly horizontal stratum having definite upper and lower planes. They were moreover conspicuously unwaterworn. The ancient surface supporting this stratum differed slightly from the overlying deposit both in color and composition, being somewhat more clayey than the latter. Its stony constituents were also rather more waterworn and graduated rapidly downward into increasingly coarse and abundant pieces—facts finding explanation in Mr. Warren Upham's statement of the relations existing between the retreating ice-sheet of Minnesota and the Mississippi river-gravels at Little Falls.[1] The surfaces of the deposit were so uniform that when the hand, intruded horizontally, was raised or lowered by only a few inches, the supply of quartzes wholly failed. Had they been transported hither by water, either when their present sandy bed was dry land or the soft bottom of a river or pond, they would presumably have been more or less diffused through associated material, would have penetrated the underlying gravels confusedly, to varying depths, and would present many waterworn surfaces. These conclusions were by no means purely conjectural, but were based upon the

[1] Palæolithic man in eastern and central North America. The Recession of the ice-sheet in Minnesota in its relation to the Gravel Deposits overlying the Quartz Implements found by Miss Babbitt at Little Falls, Minn., Warren Upham, p. 436. Reprint from Proceedings of the Boston Soc. Nat. Hist., Vol. XXIII.

present behavior of such fragments under similar, though less rigorous conditions.

Second, the composition of the stratum supported the same view. It was made up of a multitude of quartz chips and splinters and, resting upon and among these, thousands of larger pieces, numbers of which have since been identified as implements. In illustration of the immense quantity of the larger fragments I may repeat that, at one time, I collected of them for study, by actual count, about one thousand pieces which had been newly washed out by the rains, while leaving probably some hundreds stranded among the stones in their pathway, or enveloped in the subjacent sands. Yet this did not diminish the average yield of the stratum beyond the immediate margin of erosion.

These quartzes were unlike the indiscriminate product of long-continued disintegation, not only in their vertical limitation, but also in their shape and their very moderate size; none of them being too heavy to be carried easily in one hand. Much the largest of the whole were scattering specimens weighing two or three or more pounds. Judging from their form, these might have been utilized as pounders or weapons. With the single exception of a small waterworn quartz bowlder which was not included in the stratum but which, as inferred from its position, might once have been so, no mass greater than these was found during an investigation continued at intervals down to 1885.

Third, the assorted condition of certain of the specimens supplied proof positive of human interference, While some particular forms, as pounders and the like, were scattered through all parts of the deposit, others occurred only, and others still mainly, in groups each of which represented a particular type of specimen. These little clusters most frequently occupied a surface of only a few square feet. They appear in every part of the stratum explored. Each group, besides the ordinary debris, contained one or two, or sometimes, a considerable number of relatively perfect specimens associated with others less differentiated in shape which were perhaps spoiled and unfinished implements. Occasionally also some single group comprehended quite distinct modifications of the primal type. Thus among the first recognized implements of the place were a few plano-convex specimens corresponding in shape with those originally figured by Dr. Abbott as *turtle-backs*. In close proximity to these, appeared pieces having the same general contour, but apparently spoiled by the loss of too thick a flake; others which were probably unfinished; others with one extremity differently shaped; and others still presenting two convex surfaces.

From the above premises it was at length concluded that the quartz stratum represented an ancient work-site of man. A peculiar distribution of certain choice varieties of material, together with the unmistakably worn condition of edges and angles of occasional specimens, further corroborated this theory.

The process of inhumation must have been a most gentle one, undisturbed by the action of currents; a fact to which we no doubt owe the singularly perfect preservation of this mass of remains. It is as though

the infant Mississippi had formed a lake-like expansion at Little Falls, perhaps through encountering some obstacle at the south. It appears not improbable that the quartz-workers were driven from this spot by the encroaching waters. We cannot suppose them to have abandoned their industries and properties here, except upon necessity, real or supposed, nor would they have been likely thus to assort their belongings but with the prospect of repossession.[1]

GLACIAL ORIGIN OF LITTLE FALLS QUARTZES.

The glacial origin of the Little Falls quartzes is, strictly speaking, not a matter at issue. So far as I know, it has never been questioned by competent geological authorities that the including formations belong to the last ice-age. Mr. Warren Upham, who has devoted six summers to a personal examination of the region, concurs with the state geologist upon this point. He says:—

"My observation and study of that region convince me that the rude implements and fragments of quartz discovered at Little Falls were overspread by the glacial flood-plain of the Mississippi river, while most of the northern half of Minnesota was still covered by the ice, contemporaneously with its formation of the massive moraines of the Leaf hills and with the expansion of Lake Agassiz on their west side, respectively sixty and eighty-five miles west of Little Falls."

In his admirable monograph, Mr. Upham states the conditions rendering possible the occupation of this spot, and those causing its abandonment. I take leave to condense from this publication such results of his research as are necessary to a clear comprehension of the present case.

As shown by Mr. Upham, that portion of the last great glacier which extended across Minnesota from north to south ended in a vast ice-lobe descending at its utmost southern limit to the neighborhood of Des Moines, Iowa, and forming there the Altamont *terminal* moraine. During its retreat thence to the northern boundary of Minnesota, there ensued ten distinct periods of halt, or perhaps of re-advance, defined by as many *marginal* moraines extending in irregular east and west curvatures across the country. Three of the eleven moraines have their extreme terminus in Iowa, the remaining eight in Minnesota. The seventh halting-place, proceeding northward, was at the Dovre moraine, the south-east shoulder of which rests upon Kan-da-*yo*-hi county, some distance below Little Falls. In its recession thence to the eighth and ninth moraines lying to the north, the glacier disappeared entirely from the Little Falls river-basin, leaving behind it the present underlying sheet of till.

The two last mentioned moraines are merged in one at a portion of their course known as the Leaf Hills. This range projects southward from Fer-

[1] "Description of some palæolithic quartz implements from central Minnesota," Section H, Proceedings of A. A. A. S., 1884. "Vestiges of glacial man in Minnesota," American Naturalist, 1884, June, July numbers. "Ancient quartz workers." American Antiquarian, 1880, Vol. III, No. 1.

gus Falls in a semicircle stretching fifty miles to the east, and attaining its extreme southern limit, "nearly due west of Little Falls and half-way between the south and north borders of Minnesota." From each extremity of this common range, the eighth and ninth moraines diverge as independent formations. Eastward, the eighth, or Fergus Falls moraine, has been correlated with conspicuous hills in Morrison county, five to fifteen miles from Little Falls, measuring to the east, north and west. The ninth or, as it is called, the Leaf Hills moraine, stretches across the northwest of Morrison county and proves the originating glacier to have stood at its nearest approach only twenty miles distant from the quartz stratum.

Mr. Upham further shows that the modified drift underlying the bed of remains and resting upon the till was deposited by floods from the melting ice-sheet, when at its eighth halting-place, and that the superior accumulations were brought down and spread out during the period of retreat immediately following.

GLACIAL RÉSUMÉ.

In *résumé*, the above order of events is as follows:

First.—The ice-sheet, after a withdrawal northward of something like three hundred miles, made a seventh halt at the Dovre moraine, below Little Falls. A further retreat to the eighth moraine, lying above it, left the river-valley divested of ice but covered with a sheet of till.

Second.—The floods issuing from the melting glacier, at its local terminus among the Morrison county hills, spread out the debris at its base upon the till forming the bed of the Mississippi, here and then, about three miles in width. Eventually the floods decreased; the river deepened its channel; lateral portions of the river-bottom became flood-plains.

Third.—The Little Falls man set up his industries upon the surface thus made ready. As suggested by both Winchell and Upham, he probably established himself here because of the quartz veins in the vicinity, no satisfactory outcrop of the mineral appearing in Minnesota south of this place.

Fourth.—At the period of glacial recession immediately succeeding, the floods again overflowed the river-plain, and with their finer deposits sealed up the site and the product of the quartz-worker's labor.

SIGNIFICANT POINTS OF THE LITTLE FALLS QUARTZES.

These remains have possible phases of significance not yet, perhaps, fully apprehended. It is a mooted question with archæologists whether the man of the drift followed up the melting glacier to the north, The quartz-workers, supplying a case in point, answer the inquiry so far as can be done by a single example. They had pushed their way to the very foot of the ice-mountain when it stood three hundred miles north of its original terminus in Iowa. They dwelt here for at least a portion of the year at a time when the Leaf Hills were in accumulation only sixty miles to the west, when the glacial Lake Agassiz was at its maximum height eighty-

five miles to the west, and when the Minnesota glacier had already withdrawn half-way from its southernmost limit to "the district across which the Nelson river flows to the Hudson bay." The prehistoric page opened to us by this quartz-working folk is chiefly however a page of questions. Did the race thus haunt the outskirts of the great ice-fields from choice? Had it, during the long ages of glacial encroachment, so acclimated itself to frigorific conditions as to prefer them? Or was it crowded northward by hostile drift-men on the south? What were its powers and habits of locomotion? Did its members, like birds of passage, flit from south to north and back again with the seasons? If not, were they endued by nature with a covering of hair, or had they already learned to protect their bodies with the skins of beasts?

If, as suspected, the primal savage developed skill in his ancient habitats, we should for obvious reasons be prepared to find possible traces of advancement in the northern branches of the race. Among the first progressive steps of primitive man would be such modifications of his *stone fist* as would adapt it to special uses: like cutting, pounding, scraping, and thrusting. This has appeared to me to be distinctly the status of the Little Falls quartzes. According to every indication, the artificers were not solitaires. There existed among them a society in nucleus if in no advanced stage of evolution. They had plainly attained to some notion of a common interest, of ownership, and even of a sort of order.

Another progress in methods would be the adjustment of the stone fist to an arm of wood, the result being of course a compound instrument. I may observe that I could only account for certain of the quartz forms upon the hypothesis that this is their actual character. At a first glance, the theory that the quartz-workers had made any advance whatever in their handiwork seems directly opposed by the extreme rudeness of their products, a rudeness which has militated so strongly against the recognition of their work by tyros in palæoliths. Let us not forget, however, that their general workmanship represents two separate elements; the skill of the artificer, and the quality of the manipulated material. Now the Little Falls quartz veins supply a mineral many of whose natural forms require but slight modification to adapt them to the uses of savage life; and we may reasonably infer that fragments which needed but little fashioning, would receive but little fashioning. In other cases, where no small labor has been expended upon objects, the flaking process is often so disguised by the irregular fracture of the quartz as to be almost inappreciable. Such implements show the work put upon them in a far lower degree of course than those of material having a definite fracture, like the different varieties of flint and the Trenton argillite.

Because of its geographical position and other characteristics, the deposit above discussed is not unlikely to supply a basis of comparison for future palæolithic finds in the northwest. Its former contents should therefore receive careful examination with reference to possible original types. It remains also to be correlated with glacial systems on the east and the west, and to be studied in its relations to the semi-superficial quartz debris in the neighborhood.

EVIDENCES OF THE SUCCESSOR OF PALÆOLITHIC MAN IN THE DELAWARE RIVER VALLEY.[1] By Dr. CHARLES C. ABBOTT, of Trenton, N. J.

[ABSTRACT.]

RESULTS of a careful survey of a wide extent of territory in New Jersey, in the valley of the Delaware and other rivers of the state, showing that the circumstances under which argillite implements of a neolithic type are found as a rule, indicate that such "finds" or village sites are of an earlier date than those known to have been occupied by the Delaware Indians immediately preceding and during historic times.

With exhibition of specimens.

DESCRIPTION OF A GOLD ORNAMENT FROM FLORIDA. By A. E. DOUGLASS, Museum of Natural History, New York, N. Y.

[ABSTRACT.]

DESCRIPTION of a gold gorget found on the Kissimmee river, Brevard county, Florida. Testimony to show that Florida was known at the beginning of the sixteenth century to be destitute of mines or placers of gold. Testimony of the first explorers as to the presence of gold there, and as to its probable source. Reasons for concluding that none of the gold then found in Florida could have come from North Georgia. Never found in the latter state by the earliest expeditions therein, either in use among the natives or in mines or placers. What the Indians described as gold proved to be copper. Abundance of wrecks on the Atlantic coast of Florida during the sixteenth century, and great amount of treasure secured from them by the Indians. The character of the alloys in different specimens of metal now found resembling that of the product of the Spanish main confirms the views now entertained. The gold finds in Florida are very few; in most cases associated with objects of other metals or material only procurable from wrecks, or with such admixture of alloy as ensured their fabrication second-hand from the product of the Spanish main. Inference that all the known objects of gold found in Florida could only have come from that source.

A PORTRAIT PIPE FROM CENTRAL AMERICA. By A. E. DOUGLASS, American Museum of Natural History, New York, N. Y.

[ABSTRACT.]

APPARENT rarity of pipes, with bowls set angularly upon the stem, in Mexico at the time of the Spanish Conquest. Testimony of early historians and explorers as to the prevailing modes of smoking in Mexico and Central

[1]Printed in Popular Science Monthly for December, 1889.

America. Tubes only of perishable material generally referred to. Tubes of stone used on the California coast. Pipes however with bowls, presumably of that period, met with occasionally in collections of Mexican relics. These are of terra cotta, frequently highly glazed and ornamented with incised lines.

Description of a pipe in a black slate, with three faces carved upon the bowl, found at a depth of twenty feet in debris of ancient Indian workings in a pre-Columbian gold mine in San Salvador, Central America. The faces there presented identical with those of early Indian tribes of that region not yet extinct. Attestation of the discoverer of this pipe to the circumstances under which it was found, which warrants the writer in considering it a veritable pre-Columbian relic of great ethnographical interest.

PREHISTORIC JASPER ORNAMENTS FROM MISSISSIPPI. By Prof. R. B. FULTON, University of Mississippi.

[ABSTRACT.]

A BRIEF account is given of the ornaments of this material which have been found in Mississippi at various times, with statements regarding their peculiarities and the difficulties in their manufacture, and reasons for supposing the work to have been done by one lapidary. A set of perforated jasper beads is shown, the total length of all the perforations being twenty-eight inches. Specimens of wrought quartzite of various structure and colors from southwestern Mississippi are shown, illustrating the materials found in the gravel beds of western Mississippi and utilized by the aborigines.

NOTES ON ABORIGINAL FIRE-MAKING. By WALTER HOUGH, U. S. National Museum, Washington, D. C.

[ABSTRACT.]

Two sticks are the tools of the aboriginal fire-maker. Wherever the lower races of men have been observed making fire they have, except in very few instances, been found to use this simple process of twirling one stick upon another.

There is a widespread belief among scientific men that this way is difficult. An extensive collection of the descriptions and personal testimony of travellers who have seen it done, shows that in almost all cases fire was easily and quickly made. Gauged by the observer's ability to repeat the experiment, it seems very hard; so it is when judged by the time and work

taken by some tribes — who seem to have to some extent forgotten the knack.

Reducing this inference to a practical test the writer has repeatedly made fire on the wooden apparatus, quickly and with ease. With the simplest form, two sticks, he has made fire in twenty seconds; with the bow drill in less than five seconds.

Aside from the knack required we must have dry, combustible wood of the right kind; that which is semi-decayed is best. The friction of the wood grinds off a small heap of charred dust, in which the fire rises when the heat generated reaches 450,° or more.

Inferences:

1. Since fire-making by gyration on wood is easy, and almost universal among inferior races, there is a strong probability that it is the primitive discovery (invention).

2. The *culte de feu* and other instances of careful fire preservation are not caused by the "almost impossibility of making fire" of some authors, but is perhaps based on some feature of social economy.

The fire-making apparatus of the Indians and Eskimo were exhibited, and fire was made with the several kinds.

ABORIGINAL MONUMENTS OF NORTH DAKOTA. By Prof. HENRY MONTGOMERY, Ph.B., Grand Forks, Dakota.

[ABSTRACT.]

ON the morning of the 10th of July, 1883, I began my explorations of the aboriginal mounds of the Territory of Dakota, by opening the largest mound of a large group situated near the source of Forest river in Walsh county. Since that time I have excavated and explored thirty-nine ancient artificial mounds throughout North Dakota. Besides these, I have examined specimens obtained from at least ten others, and I have personally inspected the exterior of forty-eight more mounds in the same region. The mounds explored were in Walsh, Ramsey, Benson and Grand Forks counties. They may be divided into 1, BURIAL MOUNDS; 2, SACRIFICIAL MOUNDS; 3, BEACON MOUNDS. Only one Beacon mound occurred among them. There was one well-marked sacrificial mound, and another not so well-marked. The remaining thirty-six were burial mounds.

1. BURIAL MOUNDS. *Structure, situation and contents.* Of the mounds of sepulture there are two or more kinds, descriptions of which are here given.

(*a*) The ordinary burial mound, external views of which may be seen in figures[1] 1, 2 and 3, consists of a circular, rounded or conical heap of earth, mostly rich, black soil from the prairie, clothed with grass and rising generally to a height of several feet above the surrounding land. The height

[1] The illustrations here defined were shown at the meeting, but are not reproduced in this abstract.

ranges from a few inches to twelve feet, and the diameter from thirty to ninety feet. In each burial mound, one or more vaults or graves occur, in which human skeletons and various implements, ornaments, trinkets, etc., are found. If but one vault or grave occur, it is nearly always in or about the centre of the mound. If two or more vaults occur, they are eccentric in situation, and from a few inches to several feet distant from one another. The vault is circular; in only one instance, have I seen it to vary from the circular or cylindrical, well-like pit, and in this case it was merely a little irregular. I have never found the vault to be rectangular or square. The vault is a well-like excavation in the ground, having a calcareous bottom and wall, and often also a calcareous covering consisting of a whitish-yellow layer two or three inches in thickness. The bottom of the vault is overspread with bark of some tree, and the vault contains on its bottom nearly a foot of pulverized yellow clay, which is surmounted by rich, black soil, similar to that constituting the general soil of the region. A vault ranges from three feet to seven feet and five inches in diameter, the average being about four feet. Its depth ranges from two to four feet. Its bottom is often six or eight feet below the top of the tumulus, and in one case more than twelve feet. For many years past, in my work of excavation, I have proceeded in this way:—I begin to dig and remove the sod and dirt from the top of the mound to a depth of one foot, and over an area fifteen feet in diameter, with the centre of the mound for its centre. Then another layer or thickness of like size is removed, and the depth is increased, foot by foot, always keeping a level floor in order that the location of the vault or vaults may be more readily determined. Wood is found from one to two feet down. This wood consists of poles or young trees, varying in diameter from three to ten inches. They were charred on their ends, and over the greater portion of their surfaces. When the yellow subsoil is reached, the loose dirt is carefully scraped off, and the vault may be at once perceived as a circular spot of soft, black soil, surrounded by a hard, yellowish-white clay. This is shown in figures 4 and 5, which are views of a mound on R. 65, T. 158, Sec. 12, Ramsey County, North Dakota. These were taken immediately after the vault had been located by the writer. Then I proceeded to remove the dry, loose, powdered, black dirt, and soon came to the yellow clay containing a human skeleton, one earthenware urn, one shell scoop, a birch-bark basket, a turtle shell, and several shells of large, fresh-water Unios. Here, as in all other instances where they occurred, the urn, basket and spoon were with the skeleton of a female.

The skeleton is generally found in a crouching posture, with back against the wall and face towards the centre, the ossa innominata upon the tarsal bones, and the shoulder, head and hands upon the knees. The other relics are found beneath or near the skull and breast.

Up to the present time, Aug. 10, 1889, I have explored twenty-four vaults, twenty-two of which were of the character just described, and the remaining two were slightly different. These twenty-four vaults were contained within twenty mounds.

(*b*) The second kind of burial mound differs chiefly in having no wood

and no burial-chambers, and in the bones being greatly broken and greatly scattered. I have explored six of this class.

(c) There is, perhaps, a third kind of burial mound in this district. But, as yet, I have been unable to make a separate class for it. It would appear to be rather a variety of the second kind, than to form a distinct kind by itself. Its chief distinguishing characteristic is the possession of a layer of yellow clay two inches thick, which extends through the greater part of the mound and seems to overlie many human skeletons. It may possibly correspond to the covering of the vault or to the vault itself described in the first class. In this kind, however, no real vault or excavation occurs, and the layer of yellow clay is found two or three feet above the original surface of the ground. For convenience' sake it may be temporarily placed between the two preceding classes, until other mounds of similar character shall have been carefully studied. I have explored ten mounds of this kind.

The burial mounds, like all the others, are situated upon high ridges and hills, composed often of drift clays and boulders, and sometimes of gravel and sands. The position of more than thirty in Walsh county, is shown on the accompanying plans. [The location, dimensions, structure and contents of each burial mound were given in detail, and many specimens and photographic views of the crania, the vessels of pottery, the copper, stone, shell, bone and other articles taken from these mounds by the writer, were exhibited.]

2. Sacrificial Mounds. The only really well-defined sacrificial mound which has been excavated and explored by me in this region, occurred on the south side of Devil's Lake, between Fort Totten and Sully's Hill. It was operated upon, September, 1887, and exhibited the following dimensions, characters and contents. [Here the particulars were enumerated.]

Another mound, somewhat resembling the foregoing, was opened near Sweet Water Lake in July, 1889.

3. Beacon Mounds. The beacon mound explored by the writer was situated in Benson county, and near Sully's Hill. It was operated upon in September, 1887, and exhibited the following dimensions, characters and contents. [Here the details were given.]

The Winnipeg mound region: being the most northerly district where mounds have been examined on the American continent.

By George Bryce, LL D., Manitoba College, Winnipeg, Manitoba.

[ABSTRACT.]

The Winnipeg mound region, examined by the writer, includes a district some four hundred miles from east to west, and running from the International boundary line northward, the furthest north mounds seen (but by another observer) being in about 52 N. latitude. The waters of this great

region run into Lake Winnipeg, and the writer has here seen some sixty mounds, of which he has opened ten. The greater part of the work of excavation has been done in connection with the Manitoba Historical and Scientific Society. The mounds observed have been chiefly on the Rainy, Red, and Souris rivers. Numerous skeletons have been exhumed, and a skull from the mounds is before the Association, seemingly brachycephalic.

(1). Unmanufactured articles found:

Large quantities of charcoal, red and yellow ochre, and birch bark charred.

(2). Manufactured articles:

(*a*) *Stone implements* are numerous; *e. g.*, knives, gouges, chisels, axes, malls, conjuror's tubes, and a set of gaming stones.

(*b*) *Bones:* Breast ornaments of various types, bone whistles, beads, etc.

(*c*) *Shells:* Columella of conch from tropics. Tropical Natica and Marginella shells made into beads, wampum and breast ornaments.

(*d*) *Horn:* Fish spear.

(*e*) *Pottery:* Numerous fragments of marked pottery; one complete cup from Rainy river mound.

(*f*) *Copper:* Copper implements, all of native copper, which on examination by the microscope prove to contain silver, and are so identified with Lake Superior native copper. Circlet of native copper around skull in a Souris river mound.

(*g*) *Miscellaneous:* Near one skeleton, two lumps of arsenical iron pyrites, no doubt used as sacred objects; fragment of Baculite and a good sized Inoceramus in a Souris river mound, no doubt valued for their rich, nacreous covering.

Summary:

1. All mounds of this region are circular or oval.
2. Mounds are all on prominent headlands or ridges, hence for *observation.*
3. Majority of mounds contain skeletons, hence for *sepulture.*
4. Half-breeds of Red river say mounds belonged to the Mandrills, no doubt corrupted for Mandans, to whom extinct mound builders seem to have been related.
5. There is a persistent tradition among all the Indians, that the mound builders perished from small pox. This probably results from confusion of the facts that the mound builders were related to the Mandans, and that the Mandans of the Missouri some fifty years ago were almost exterminated by small-pox.
6. All mounds in this district are found in agricultural areas, showing mound builders to have been tillers of the soil.
7. Mound builders were probably Toltecans.
8. These mound builders, probably disappeared at the time of the destruction of the Hochelagans, Eries, Neutrals, etc., being crushed out between Sioux and Iroquois from the south, and the Ojibways and Crees from the north, say three hundred years ago.
9. Certain mounds from state of the bones, and from certain topographical and geological considerations, it is likely date the beginning of their central parts to four hundred years before that date.

STEATITE ORNAMENTS FROM THE SUSQUEHANNA RIVER. By ATREUS WANNER, York, Pa.

[ABSTRACT.]

THE writer exhibited some steatite ornaments consisting of the following: disk, bead, perforated pieces of steatite dishes and several other ornaments, one of which rudely represented a human face.

From a close inspection of the various articles, the conclusion was drawn that the disks were made out of fragments of steatite dishes, and that probably the other ornaments were constructed out of steatite obtained from the same source.

THE "MIDE'WIWIN" OR GRAND MEDICINE SOCIETY OF THE OJIBWA INDIANS. By W. J. HOFFMAN, M.D., Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

THE so-called secret societies of the Ojibwa Indians have already been mentioned by Schoolcraft and other writers. One of the most important of them is the Midē'wiwin or Grand Medicine Society. In this is preserved the most interesting collection of myths pertaining to the Ojibwa cosmogony; the migration of the Anish'inâbēg, their ancestors; the origin and constitution of the society; the ritual of initiation and the secrets of prophecy. Mnemonic charts, pertaining to the above, have been collected and explained by the chief Mide' of the society.

Instead of being limited to a single degree, being all hitherto disclosed, this body is graded into four distinct degrees with the collateral branch—the Ghost Society — through which candidates may, under special circumstances, obtain the privileges of the first degree.

The writer has for two years been engaged upon official ethnologic investigations among the Ojibwa, and has secured very full and complete notes of the entire proceedings of this society, in consequence of which he this year resumes and hopes to conclude his researches, visiting the Ojibwa of the Upper Lakes, with the promise of being fully initiated into all the degrees and will add to his present notes the results of his initiation during the present summer to form part of the paper offered.

THE MISSIONS AND MISSION INDIANS OF CALIFORNIA. By HENRY W. HENSHAW, Bureau of Ethnology, Washington, D. C.

[ABSTRACT].

THE paper treated of the mission establishments, the purpose they were intended to subserve, briefly described the natives and their aboriginal mode

of life. It described the methods of obtaining neophytes, the manner of converting them to Christianity, the discipline administered; also the labor required of them and their instruction. It finally discussed the causes of the failure of the missions and the marked decrease of Indian population.

A map was exhibited showing the location of the missions and the number and distribution of the linguistic families to which the mission Indians belonged.

SIOUAN TERMS FOR "MYSTERIOUS" AND "SERPENT." By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

THE attention of the writer having been called to the article on "Serpent Symbolism" in the Iroquoian languages by Mr. J. N. B. Hewitt, published in the American Anthropologist for April, 1889, a similar investigation of the Siouan terms was made, the results of which are now presented. This article will be published in the American Anthropologist.

The following languages and dialects are compared: Dakota (Santee, Yankton and Teton dialects), Dhegiha (Omaha and Ponka, Kansa, Osage and Kwapa), Tci-we-re (*i. e.*, Iowa, Oto and Missouri) and Ho-tcañ-gara or Winnebago.

The term "Wa-kan" (or some derivative) is found in all these languages, but it varies in meaning. By a reference to the author's paper on "The Comparative Phonology of Four Siouan Languages," read at the Montreal meeting of 1882 and published in full in the Smithsonian Report for 1883, it will be seen that the Winnebago is probably the most ancient of the four languages. In that as well as in the Tci-we-re, *serpent* is still called wa-kan. The other languages have different words for *serpent*, but the Dakota has retained wa-kan as meaning *mysterious*, though that language seems to have changed more than the Dhegiha and Tci-we-re.

"GENS" AND "SUB-GENS AS EXPRESSED IN FOUR SIOUAN LANGUAGES. By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

IN the American Anthropologist for April, 1888, appeared an article entitled, "Meaning of the Words for Gens in the Iroquoian and Algonquian Tongues," by J. N. B. Hewitt, of the Bureau of Ethnology. In it Mr. Hewitt stated that in nearly all the Iroquoian languages the word for gens

also signified clay or mud, and that he had found a like similarity in the Algonquian. This is not the case in the four Siouan languages under consideration.

The Dakota *gens* is called o-ce′-ti (o-che′-ti), literally, *fire-place;* hence, the national name O-che′-ti sha′-ko-win, *Seven Fire-places,* comprising the seven original gentes, now tribes, Mdewakantonwan, Wakhpekute, Wakhpetonwan, Sisitonwan, Ihanktonwan, Ihanktonwanna and Titonwan. Among these, the *sub-gens* is known as the ti o-shpa-ye, *a group of those who camp by themselves, apart from the main body.*

The Omaha and Ponka call the gens taⁿ′-waⁿ-gdhaⁿ u-ba′-naⁿ, or taⁿ′-waⁿ-gdhaⁿ u-ba′-te, *a village* or *group of people springing from a common stock.* By the way, ba-naⁿ′ and ba-te′ refer to *a clump of trees springing from a common root* or *stump. All the gentes,* taken as a whole, are described as taⁿ′-waⁿ-gdhaⁿ ba-naⁿ′-naⁿ, or taⁿ′-waⁿ-gdhaⁿ ba-te′-te. The *sub-gens* is called either taⁿ′-waⁿ-gdhaⁿ u-ki′-gdha-sne [*a segment of a village,* or *one of the parts into which a stump has been split* (u-ga′-sne)], or u-ne′-dhe, *a fire-place.* The Kansa have the term, taⁿ′-maⁿ u-ki′-pa-te, sociative in form and therefore applicable to the *sub-gens* rather than to the gens.

The Osage tell of their three grand divisions, the Tsi′-cu u-tse pe-dhŭⁿ′-pa (*Seven Tsishu Fire-places*), the Hañ′-ka u-tse′ pe-dhŭⁿ′-pa (*Seven Hanga Fire-places*), and the Wa-ca′-ce u-tse′ pe-dhŭⁿ′-pa (*Seven Osage Fire-places*), all twenty-one gentes being in the Osage nation or confederation. The writer has gained the names of sixty-seven gentes and sub-gentes of the Osage, but not the term for sub-gens.

The Tci were tribes (Iowa, Oto and Missouri) use the term ki-kra′-tce for *gens,* as Wa-kaⁿ′ ki-kra′-tce, *They call themselves* (after a) *Serpent, i. e., the Serpent* or *Snake gens.* Their name for *sub-gens* was not obtained though each Iowa gens had four sub-gentes, whose names (excepting those of one gens) have been recorded, and there are still four sub-gentes in one Missouri gens.

The Winnebago name for *gens* is i-ki′-ka-ra′-tca-da, answering to the Tciwere ki-kra-tce. Hence, Ta′ i-ki′-ka-ra′-tca-da, *They call themselves* (after a) *Deer,* or *the Deer gens.* No name for *sub-gens* has yet been found by the writer, though there are sub-gentes in the Bird gens.

[To be printed in the American Anthropologist.]

INDIAN PERSONAL NAMES. By Rev. J. OWEN DORSEY, of Takoma Park, D. C.

[ABSTRACT.]

AT the Ann Arbor meeting of this Association in 1885, the writer read a paper on the subject of Indian personal names (published in full in the Proceedings for that year). A letter from Professor Chamberlain of To-

ronto induced the writer to undertake the preparation of an extensive monograph on the same subject, to be published by the Bureau of Ethnology. There will be six lists, in which the Indian names will precede their English meanings: Winnebago, 380 names; Iowa, Oto and Missouri, 506; Kwapa, 15; Osage, 470; Kansa, 593; Omaha and Ponka, 1182. These will be followed by a general list of the 3146 names, in which the English meanings will precede the Indian originals. Several examples are given. Reference is made to the connection between the myths and some of the personal names. Certain classes of names are treated in detail, among which are color names, iron names, whirlwind names, thunder-bird names and the names of composite beings. One of the last, Moon Hawk Female, reminds the student of an Egyptian hieroglyphic. Genealogical tables of gentes of two tribes are referred to in the paper and will be given in full in the monograph.

ONOMATOPES, INTERJECTIONS AND PHONETIC TYPES. By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

THIS paper treats of the sound-roots (onomatopes), interjections and phonetic types of the Omaha and Ponka dialect of the Dhe-gi-ha, a language of the Siouan family. Whenever possible, the writer has given the Indian notation of the sound associated with the onomatope. While many roots now denote the effects of certain acts, it is very probable that some of them originally referred to the sounds made in producing those effects. Examples are given. An English writer of the last century collected a number of examples in his own language, to show that a certain collocation of consonants at the beginning of a word generally designates the class of ideas intended to be conveyed by it. Thus, *st*, idea of *rest*, *stability*, as in stand, stay, stop, stick, still, stall, stool, etc. (also idea of *motion*, as shown in words given by Horne Tooke); *sl*, idea of sliding, etc., as in slip, slide, slime, slippery, etc. Compare words in *gl*, glance, glide, etc. The writer claims that similar phonetic types exist in the Dhe-gi-ha and cognate languages.

PLACES OF GENTES IN SIOUAN CAMPING CIRCLES. By Rev. J. OWEN DORSEY, Takoma Park, D. C.

[ABSTRACT.]

IN the camping circles of the various Siouan tribes there is no uniform order of gentes. When we compare the customs of the several tribes, we are led to ask several questions: 1. Have not certain gentes shifted their

camping areas? 2. Has there been any consolidation of gentes or subgentes? 3. Has there been segregation or differentiation of gentes or subgentes? 4. Are there instances of emigration from one tribe to another of a common stock? 5. Has a new gens been formed by the adoption of foreigners (*i. e.*, those of another linguistic stock) into the tribe? The writer undertakes to answer these questions in the paper, treating first of the Dakota tribes, then of the Dhe-gi-ha, Tci-we-re and Ho-tcañ-ga-ra.

[This paper has appeared in full in the American Anthropologist for October, 1889].

THE GESTURE LANGUAGE OF THE BLACKFOOT INDIANS. By Rev. Dr. JOHN McLEAN, Moosejaw, N. W. T., Canada.

[ABSTRACT.]

DIFFERENT gestures of the Northwest Indians.
Gestures relating to tribes.
Names of tribes designated by gestures.
Gestures descriptive of some characteristic of the tribe.
Mode of reckoning by gestures.
Gestures relating to measurement of time.
Gestures relating to counting.
Hunting and war gestures.
Signalling.
Miscellaneous gestures.

ONONDAGA SHAMANIC MASKS AND THEIR USE. By DECOST SMITH, Skaneateles, N. Y.

[ABSTRACT.]

EARLY notices. Bartram (John), 1743. Morgan (Lewis H.), 1852. Turtle shell rattles used in connection with masks. Cited and figured by Lafitau, 1724. Description of masks. Masks symbolical of supernatural evil beings, called Ho^{n}-do'-i. Their aid invoked to drive away witches. They cause or remove illness. Are propitiated with feasts and sacrifices of Indian tobacco. Description of these ceremonies. Exhibition of masks and rattles.

THE IROQUOIS WHITE DOG FEAST. By Rev. WM. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

DOGS were much used in Indian feasts, especially those of a warlike or religious nature. The Mohawks sometimes sacrificed bears instead of men, and may have had a periodical feast. That of the white dog, among the

Iroquois, seems to have combined the early war and dream feast in a newer custom, of which our earliest account is in the latter part of the last century. It was a festival of the new year, and we have various accounts of it. Besides the early descriptions of the feast at its proper time, we have mention of the sacrifice in Sullivan's campaign in the autumn of 1779.

In its rites the False Faces have a prominent share, and there is an atonement for sins, a purification of houses, and often a relighting of fires. Dances occur throughout, the Onondaga feast lasting fourteen days, and the Seneca a shorter time. The Senecas kill the dog or dogs several days before the burning; among the Onondagas the strangling and burning are on the same day. Some other differences appear. Among the ceremonies are the confession of sins, naming of children, adoption of desirable persons, and a kind of prophetic gaming. The original Indian tobacco only is used at this time. The feast has greatly changed, and will soon entirely disappear.

INDIAN BURIAL IN NEW YORK. By Rev. WM. M. BEAUCHAMP, Baldwinsville, N. Y.

[ABSTRACT.]

BURIAL customs vary greatly in New York. The sitting posture was quite frequent, but in most known cases facing the east. The horizontal posture was less common, but quite as old. In both cases articles may or may not be found with skeletons. Small houses or casements were sometimes made over graves; in others there might be a low mound, often resulting in a depression. True burial mounds and ossuaries are occasional, but mostly in western and northern New York. Early graves were lined with bark; later ones with plank. Stone graves are quite rare. Several instances of radiating burial are known, mostly recent. Burial by clans is yet practised among the Onondagas, but with innovations. Reversed burial, the head downward, was rare, and may have been a punishment. Among the Onondagas witches were cast into rocky crevices, and stones were heaped over them. In the Mohawk valley several headless skeletons were found in graves on which bowlders had been cast. Stone heaps sometimes occur over graves, but these had other uses. Burial in tiers is found by Cayuga lake. Allusions to the gathering of bones and placing them under the roots of trees are found in speeches, but the Nanticokes alone are clearly described as taking up and reinterring their dead.

ALGONKIN ONOMATOLOGY, WITH SOME COMPARISONS WITH BASQUE. By ALEX. F. CHAMBERLAIN, Toronto, Ont.

[ABSTRACT.]

THE subject of comparative onomatology is of importance as an evidence of the mental acquirements of the races of people compared. It is

closely related to history and folk-lore, as both these sciences are called into play in the interpretation of names (here taken in the widest sense). Comparative onomatology, as far as regards our Indian languages, is almost an unexplored field. There are several groups which afford an inviting harvest, such as the Siouan, Iroquoian, Algonkin, with their numerous dialects. It is with Algonkin, however, that the writer of this paper intends to deal, turning to the Basque at times for useful illustrations and comparisons. The subject may be divided under several heads, viz.: (1) Names of inanimate objects of nature, earth, sea, sky, sun, moon, stars; as moon, in Cree, *tipiskâwipisim*, in Ojebway *tibigisiss*= night sun; Basque *illargi* (moon)=light of death. (2) Names of animals, birds, insects, fish, etc.: gopher, in Cree, *potatchikasew*, in Ojebway, *potatchipinggwasi* = the thing that blows up loose earth; crawfish, in Cree, *asâkew*, in Ojebway, *ashagashi* = the thing that moves backward; whitefish, *attikamek* (Cree), *atikameg* (Ojebway)=the caribou-fish (the caribou of the waters); swan, in Cree, *wâpisiw*, Ojebway *wabisi* = the white (bird); in Basque, *saguzara* (bat)=old mouse; weasel, *angereder*= pretty maid; dory (fish), *arraingorri* = red fish. (3) Names of trees, plants, fruits, etc.: sassafras, *menagwakomis* (Mississagua)=scented tree; oak, in Cree, *maskwâttik*= hard wood; a sort of willow, *mahiganâttik* (Cree)=wolf's wood; cranberry, *maskekomin* (Cree), *mashkigemin* (Ojebway)=*muskegamin* (Mississagua)=marsh-fruit; strawberry, *otchemin* (Cree), *otémin* (Mississagua) *odéimin* (Ojebway)=heart-fruit; in Basque, oak, *aritz*=the hard (stony) wood; quince *ira-sagar*, ira-apple; osier, *zume*=thin, small tree. (4) Names of implements, instruments, etc.: Bead, *manitominis* (Mississagua)=mystery-seed; chisel, *eshkon* (Mississagua)=horn; needle, in Cree *sâbonigan*, Ojebway *shabonigon*=that which pierces; in Basque, sling, *uballarri*=stone-thong; axe *aizkora*, connected with *aitz*=stone. (5) Names of seasons, months, etc.: January, in Cree, *kisipisim*=the great month, in Ojebway, *manito-gisis* = spirit-moon; May, in Cree, *niski-pisim* = month of the outarde, in Ojebway, *wâbigoni-gisis*=moon of flowers; compare in Basque: *urtarrilla* (January)=month of waters, or perhaps month of the year = principal month (?), *ostoilla*, *ostaro* (May)=month of leaves, time of foliage. (6) Names of members of the human body, etc.: thumb, in Cree, *misitchichân*, Ojebway, *mitchitchinindj*=great finger, in Basque, *beatzlodi*, *atzlodi*, (thumb)=thick finger. (7) Names of animals, plants, instruments, materials, objects, etc., of exotic origin: Horse, in Cree, *mistatim*=big dog, in Ojebway, *papajicogishi*=the animal with undivided hoof; sheep, in Ojebway, *manitanis*, in Cree, *mestjanis*=the animal with the hide that is not durable; carrot, in Ojebway, *osawichies*=yellow turnip; looking-glass, in Mississagua, *wabimotchichagwan*=where ghosts are seen; shot in Mississagua, *shishibanwing*=duck-stones. (8) Ethnic names, *Nehiyawok* (Crees) =the true, real, men; *Mississagwé*=those who dwell where there are many mouths of rivers; *Potawatomi*=fire-makers (let. we are making fire); according to Long the Ojebway call themselves *Neenawesik*=they who speak a natural language; compare the Basque *euskara*=the Basque language, *euskaldun*=a Basque (*euskara*, according to Humboldt=the language par excellence). (9) Personal names: *Ogimabinesh*=chief-bird, *Asawbanung*

=stars in a cluster, names of Mississaguas at Scugog; in Basque, *Echeberri* =new house, *Echegaray*=excellent house. (10) Words of onomatopœic origin: in Cree, *wehwew* (goose), *ahâsiw* (crow), *kâkâkiw* (raven), *kokus* (hog), *sisib* (duck), in Ojebway, *wewe* (goose), *shishib* (duck), *kakaki* (raven), *kokosh* (hog). In Basque, *kakaraz*, clucking of hens, *irhinziri*= neighing of horses. (11) Words (apparently radical) of which the etymological significations are not apparent:

	(bear)	(bee)	(blueberry)	(earth)	(moose)	(porcupine)
Ojebway,	*mukwa*,	*amo*,	*min*,	*aki*,	*moⁿs*,	*kak*,
Cree,	*maskwa*,	*âmow*,	*min*,	*askiy*,	*monswa*,	*kâkwa*.

In Basque: toad *abo;* fish, *arrai;* head, *buru; ego*, wing; *gau* (night); *ibai*, river.

(12) Words denoting abstract ideas often of recent origin.

Many of the words to be considered involve questions of history (*e.g.*, the names given by the Algonkins to the English, French, Americans, etc.) or of folk-lore (*e. g.*, the names of the rainbow, milky way, etc., and some names of animals, etc., as the raccoon) and are of the greatest value in the study of the development of aboriginal ideas.

THE TWO BROTHERS: A MISSISSAGUA LEGEND. By A. F. CHAMBERLAIN, Toronto, Ont.

[ABSTRACT.]

THE writer related a legend dictated to him, both in Indian and English, by an aged Mississagua woman at Scugog Island. The tale, which is a very old one, is peculiar on account of the variety of incident and actions performed by the hero *Assemōka* (the tobacco-maker). Assemōka and his brother camped together long ago, and the former made up his mind to travel into the world. So at length he set out and after being metamorphosed into a tree, and a stick in the river (by his own volition),from which positions he is rescued by his brother, he travels (after the latter has declared he will help him no more) until he comes to a village in which all the people except a boy and a girl are dead. Assemōka finds out that they have been killed by a bad old woman who set them to fetch the white loon that dwells in the middle of the sea, a task they failed to accomplish. Assemōka obtains the white loon for the children and tells them to ask the old woman to get the chipmunk's horn; this she fails to do and Assemōka kills her. He then makes a little bow and arrows for the boy, and tells him to shoot up into the air three times which he does, and at the third time the people rise from the dead.

THE PHONETIC ALPHABET OF THE WINNEBAGO INDIANS. By Miss ALICE C. FLETCHER, Peabody Museum, Cambridge, Mass.

IN the winter of 1883-4, while I was with that part of the Winnebago tribe living in Nebraska, a party of Sauk and Fox Indians arrived to make a visit. They numbered fifteen or twenty and were in full Indian costume and bent upon enjoying old-time pleasures. I met these visitors several times; they came not infrequently to see me when I lay upon my sick bed. One of the men told me of a visit which he and some of his people had paid to the Chippawa Indians and how when they were there they had become interested in the revival of some old Indian customs and rituals which bore upon the moral training of men. He then at some length detailed to me maxims and instructions which were very like those given in certain ceremonies among the Iroquois and which were associated with the myths and legends of Hiawatha. My Indian informant had all the zeal of a new convert and talked long and earnestly with me concerning the religious beliefs which had come down from his ancestors, and he assured me that, were the pure codes of morality, such as he cited, enforced, the Indian would rise to be far superior in character to his white brother. The Chippawas, who had made so great an impression upon him, lived in northern Minnesota, but he could not tell me the English name of their band. He declared that there was a wave of religious revival passing over these Chippawas, and he was desirous of being an apostle of the new faith to the Winnebagos. As he talked and repeated the formulas of this reform movement, I was so much struck with their resemblance to the teaching among the Iroquois, that I asked him from whom the Chippawas had received these lessons? He replied: "They were taught by Indians living further to the East." Who these eastern Indians were my informant did not know. The interest of this Indian in the new religion, as he termed it, was well known to his companions, some of whom declared themselves to be its followers. There was talk of trying to interest the Winnebagos in the reform, but I think the attempt failed, although I know a few men who were approached. The demand for abstinence from all intoxicating liquors hardly suited modern taste.

I have never been able to follow up this interesting movement, or to learn more of these intertribal exchanges of native religious teachings in modern times. It was certainly suggestive as to how certain modifications and resemblances found in ceremonies of tribes living distant from each other, may have come about.

It was from these same Sauk and Fox Indians that I first heard of a phonetic alphabet existing among them and used by them to write their own language. The alphabet was spoken of as the invention of one of the tribe in recent years, but as none of the visitors could write it, I could not then obtain a copy. Within a year from the time of the departure of these guests, some Winnebagos went to visit the Sauk and Fox, and one of the Winnebagos while there acquired the alphabet and became an expert in

its use. In August, 1885, the agent of the Winnebagos wrote me: "The tribe have suddenly taken to writing their own language, and people who have never learned English have acquired this art. The people claim they took the basis of it from the Sauk and elaborated it themselves. It is a very suggestive sight to see half a dozen fellows in a group with their heads together working out a letter in these new characters; it illustrates the surprising facility with which they acquire what they want to learn."

During my recent sojourn among the Winnebagos of Nebraska, I inquired concerning this new alphabet and was told it had been learned from the Sauk, but when they first knew of it or who invented it I was unable to learn. The Winnebago, who on his visit to the Sauk first learned the alphabet, soon discovered its adaptability to write Winnebago, and he so applied it. Upon his return to his tribe, he taught others the use of it and now the knowledge of it has spread over the Winnebagos of Nebraska and of Wisconsin, and the principal correspondence of the tribe now takes place in these characters. I have seen many of these epistles.

This phonetic alphabet consists of seventeen of our letters and two new characters, making nineteen symbols in all. Thirteen of the letters borrowed are consonants and four are vowels.

Of the thirteen consonants, six only retain their English sound; these are M, N, Th, W, Y and X.

The other seven are as follows, with their equivalent sounds:

B = pee.	D = jar.	G = gwar.
K = ga.	L = R.	R = S.
T = td.		

The four vowels, a, e, i, o, have the following sound: ä, e̱, ī, o. The capital A = hah.

The two new characters are: đ = sh; *m* = rk. These sounds can best be heard in combination with a vowel. [The German đ is here used to represent the first of these characters, but it is nearer to a Roman d crossed by a long comma. The italic *m* is here used to represent the second character, but this is more like a continuous wavy line.]

đa = shar. Ka*m* = gark.

There is no spelling; the fifteen initial sounds with their four vowel modifiers form 128 combinations, like syllables, and with these one can easily write any words in the Winnebago language.

A few examples will show how this alphabet is used:

Wank shick ra,	means people;	the word is written, Wa k đi*m* la.
She shick,	means bad;	the word is written, đi cti*m*.
nump,	means two;	the word is written, no ba.
Henuka,	the name of the eldest daughter;	written, Ai no k.
Sin ne hhee,	means cold;	the word is written, Ri ni Ai.

The syllables are spaced; the words are seldom run together in the writing. It sometimes takes a little ingenuity to read a letter, as the close of the word is not apt to be marked by a wider space than that used between the syllables.

Duties have called me west of the Rocky mountains, where I am unable to trace the origin of this ingenious alphabet, which, so far as I know, has never before been presented to the public. I shall be grateful for any information concerning the use of this chart among other than the Winnebago and Saux and Fox tribes, and also concerning any similar methods in use among other tribes.

I have examined the Cherokee alphabet, thinking this one might be an outgrowth or corruption of that invented by Sequoah, but it does not seem probable to me.

The education of Indian youth in English has set Indians to thinking of how they can preserve their language, and I have seen many boys and some girls who have labored to make our English letters bend about the Indian words. It would seem as though we might in time expect several such inventions as this chart, but they will all probably have the same fate as our own childish devices to create a new language and a new alphabet.

There are many points of interest in this chart which will at once catch the eye of the students of languages, and I trust will be of some service to them and science. [See next page.]

PHONETIC ALPHABET AS USED BY THE WINNEBAGO INDIANS.

Ka = gah	Ke = gay	Ki = gee	Ko = go	Kam = gark	Kem = gake	Kim = geek	Kom = goke
da = jah	de = jay	di = g	do = jo	dam = jark	dem = jake	dim = geek	dom = joke
wa = wä	we = we̱	wi = wĭ	wo = wo	wam = wärk	wem = we̱rk	wim = week	wom = woke
xa = xä	xe = xe̱	xi = xĭ	xo = xo	xam = xärk	xem = xe̱rk	xim = xeek	xom = xörk
ta = tdä	te = tde	ti = tdĭ	to = tdo	tam = tdärk	tem = tde̱rk	tim = tdeek	tom = tdörk
ma = mä	me = me	mi = mĭ	mo = mo	mam = märk	mem = make	mim = meek	mom = moke
na = nä	ne = ne	ni = nĭ	no = no	nam = närk	nem = nake	nim = neek	nom = noke
La = Rä	Le = Ray	Li = Ree	Lo = Row	Lam = Rark	Lem = Rake	Lim = Reek	Lom = Roke
*ga = gwar	ge = Gway	gi = gwee	go = gwo	gam = Gwark	gem = Gwake	gim = Gweek	gom = Gwooke
*ra = Sah	re = say	ri = see	ro = So	ram = Sark	rem = Sake	rim = seek	rom = soke
Tha = Thä	The = They	Thi = The	Tho = Tho	Tham = Thark	Them = Thake	Thim = Theek	Thom = Thoke
Ya = yä	Ye = yea	Yi = Ye	Yo = Yo	Yam = Yark	Yem = Yake	Yim = Yeek	Yom = Yoke
ba = pah	be = pay	bi = pee	bo = po	bam = park	bem = pake	bim = peek	bom = poke
a = ä	e = e̱	i = ĭ	o = o	am = ark	em = ake	im = eek	om = oke
đa = shar	đe = shay	đi = shee	đo = sho	đa = shark	đem = shake	đim = sheek	đom = shoke
Aa = hah	Ae = hay	Ai = hee	Ao = ho	Aam = hark	Aem = hake	Aim = heek	Aom = hoke

In this table I have preserved the exact order as given me by my Winnebago friend. The order is certainly different from that in which one of my race would be apt to arrange this phonetic alphabet, but it may yield something toward discovering the secret of the origin of this curious arrangement, by revealing the manner in which sounds group themselves to the Indian ear.

A FEW NOTES UPON THE ESKIMO OF CAPE PRINCE OF WALES, HUDSON'S STRAIT. By F. F. PAYNE, Meteorological Office, Toronto, Ont.

ONE of the chief troubles to contend with in making notes upon the customs of the Eskimo is their extreme sensitiveness to ridicule, and it is therefore most necessary that you should put on your gravest expression when questioning them. Sometimes this sensitiveness is very interesting to watch. Upon one occasion when employing my favorite Eskimo, Ugaluk, as an assistant in my boat and telling him to throw out the anchor he immediately picked it up and carrying it to the bow was in the act of casting it overboard without a rope attached to it. We were just in time to stop him and naturally laughed, rather immoderately, at which he sat down in the boat and covering his face with his hands remained in that position for a long time, and was too shy to speak to us.

If offended at any time with their own people, or either of my men, they would immediately leave and without saying a word would go home and for some time they were not to be seen. We sometimes regretted that they could not be offended oftener, for most of them required continual watching when anything movable was about.

One afternoon several men entered our house and standing near the fire refused most positively to go out. Knowing that promptness of action has a good effect upon them, one of them was immediately handled rather roughly and stumbling fell as he was bundled out of the door, the others following suit. For a minute we thought there was going to be trouble; the next moment, however, they picked themselves up and all turning with smiling faces said "chimo, chimo," which means we are friends. I may add that orders to leave our house after this were never disobeyed.

Whilst, as a rule, the Eskimo looks upon the white man as born to do him favors, those met with would sometimes offer payment for our services; and for the burial of an aged relative, who died when his friends were away hunting, one of my men received the valuable gift of about two gallons of blubber which of course he accepted with many thanks. Nevertheless if an Eskimo was given an unusually valuable present, he would immediately turn round and ask for the most impossible things as though he thought you were now in a good humor and now was the time to get all he could from you.

As far as could be seen it seemed to be the general belief that all property, especially in the way of food, belonged to everybody in common and therefore, if you held more than another it was only because you or your family were physically strong enough to protect it. Few men of course would steal from one another when food was plentiful, thereby making enemies for themselves, but, when food is scarce, might is right, and all make note of the position of their neighbors caches before the winter's snow covers them.

At one time after a raid had been made upon my storehouse by some rather desperate Eskimo, my trusted friend, Ugaluk, informed me that his wife had gone to get a share of the plunder. At first we were inclined to

harangue him for infidelity but soon saw he had not the slightest idea it was wrong to receive stolen property. Upon another occasion, under similar circumstances, I induced Ugaluk to help me track the robbers and with some trouble we traced them to a deep gorge where all we could see was a large hole in the snow. This was the doorway of an igloo, ten feet below the surface, which had been covered by continuous drifting of the snow. Into this hole Ugaluk dived while I remained outside. He soon returned and asked me to follow, which I did upon my knees for some distance until I found myself in a very dirty dimly-lighted room. Sitting near the lamp was a woman and by her were three children, these being the only occupants of the place. The woman denied most emphatically any knowledge of the theft and was not moved in the least when informed that her husband would stand a chance of being shot if he took part in another burglary. Feeling that perhaps after all we were mistaken we were just leaving, when the woman called us back and holding up a small piece of salt beef said, this was all her husband had taken as unconcernedly as though she had never denied it and as though he had found it outside our door instead of having done a great deal of damage in securing it.

The Eskimo, of all races, are the most free and in no case do they consider a man their superior unless he or his family are physically stronger or are better hunters than others. These superior men are treated with little deference, though they are usually sought for in the settlement of disputes and sometimes act as public executioners. Ugaluk, who had all these qualities, was usually obeyed when an order was given by him, and we were much interested with his story of a comparatively recent execution which he undertook for the good of the community. Walking up to the offender he held him in conversation for a few minutes when suddenly drawing a knife from his sleeve he plunged it into his breast and then finished him upon the ground, afterwards carrying his body out upon his kyak and dropping it into the sea. As Ugaluk related his story in a whisper he trembled violently and it was quite evident he was haunted with certain fears.

As in civilized communities there were several restless individuals living among those we met who at different times had dwelt in many parts of the coast, one of whom at least had lived far up Fox Channel. These individuals are employed as traders and evidently are the means of keeping the language intact.

As is well known, work is pretty well divided among these people, the men doing all the hunting and making and repairing implements, while the women take part in everything else, even in the making of boats and building houses, though the more laborious part of this work is performed by the men.

When moving to a distant part of the coast a small pack is put upon each dog, and the menand women divide equally the heavy goods to be carried. When the snow is soft the dogs are shod with seal skin shoes.

The Eskimo's powers of endurance are wonderful. During the winter

of 1885–86 many of those about me were reduced to mere skeletons through starvation, and although they were helped as much as possible, several, it is to be feared, died not far from us. Some had eaten the skin covering of their bed and were only saved by an occasional seal being killed and by the few lemmings they could catch under the snow. In one instance a case of what appeared to be economic hibernating was noted. Some distance from the Observatory a woman and her son were found closely huddled together in a house completely closed and not much larger than themselves. They said they had not had any food for some time, but expected friends in a few days. Leaving what food we had we returned to the station, and extremely bad weather coming on some days afterwards, we had almost forgotten these people. Two weeks later we were reminded of them by an Eskimo having passed that way who said he had not seen them. Fearing they were dead we went over with provisions and much to our surprise found them, though little more than parcels of bones, perfectly well, and they declared they had lain there ever since. These people with others were soon stout and hearty when food became more plentiful.

In many of the narrow gravelly passes in the rocky hills, low walls were often noticed that had undoubtedly been built many years ago. These were in a straight line from one hill to another and were usually nothing more than single stones about a foot high placed close to each other. Many conjectures as to their use were made and taking Ugaluk to one of these walls one day he informed me that many years ago when large numbers of Eskimo lived here and wood was extremely scarce some would bind sharp stones to their feet and lying upon their backs behind these walls others would drive the deer, which were then very numerous, and as the deer passed over the walls the hidden hunters would strike with their stone-tipped feet and would often kill many of them in this way. Regarding the scarcity of wood it may be added that even now many Eskimo have not harpoons because they cannot procure a piece of wood large enough for a handle.

Having often heard of the dislike the Eskimo is believed to have to a white man exploring the graves of their dead, we determined to test this and purposely went with several Eskimo, passing near where a number were buried. Here I stopped at one grave which had evidently long ago been visited by wolves or dogs, for the covering of stones had been dragged away and the bones were scattered in every direction. To my surprise the Eskimo looked on quite unconcernedly as I turned the skull and bones over with my stick, and, if anything, they seemed rather amused than otherwise. Suddenly I feigned an expression of fear, and while they looked at me made a bound forward, screaming as I fled. In a moment they were after me screaming apparently in greatest terror. Soon stopping, however, I burst into laughter and was immediately followed by all excepting the children who evidently could not see the joke, nor would they return to the grave. During the remainder of my stay here we often examined other graves, but from a warm attachment for the dead, as well as for the living, not a bone was ever removed.

SHINTO: THE RELIGION OF THE JAPANESE. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

THE paper read is itself an abstract of a longer article in which the mythologic system of the Japanese is considered more fully, and the influence of the beliefs of the people upon the national character discussed.

The system begins with three deities formed spontaneously in space, after which come two creator gods, who, by natural processes, give birth to the islands composing Japan and afterwards to a host of deities to govern it. Some very interesting myths are related, the significance of which is not very clear and finally the succession of generations concludes with the birth of the first Mikado who is a descendant of the sun, or of the goddess Amaterasu, the deity of the sun.

The native chronology runs back to 660 B. C., and the mythologic lore purports to go back for about 10,000 years more. But no dates in Japanese history can be relied upon earlier than 400 A. D., when the historic era may be said to begin.

The subject cannot be satisfactorily presented in a short abstract, as the conceptions of deities and their conduct are peculiarly Japanese and require to be understood from a Japanese and not from an Aryan standpoint.

THE ANCIENT PIT-DWELLERS OF YEZO. By ROMYN HITCHCOCK, Washington, D. C.

[ABSTRACT.]

THROUGHOUT the Island of Yezo and extending north into Saghalin and through the chain of islands, extending northeast, known as the Kuriles, peculiar excavations in the ground are found. These were first observed by Mr. Blakiston, about 1872, but have since been noticed by others. In the course of a long journey in Yezo, during the summer of 1888, the author observed many of these pits and made efforts to obtain remains of pottery, shells, etc., from pits near Nemuro, and on the Island of Yeterof, but without success.

The pits are supposed to be the remains of dwellings which, according to Aino tradition, and perhaps also to certain references in Japanese literature which may bear the same interpretation, were occupied by the predecessors of the present inhabitants of Yezo.

The only known representatives of people inhabiting dwellings of the kind are a small colony on the island of Shikotan, originally from the Kuriles. This colony was visited by the author and the dwellings were carefully examined.

A Japanese writer has also described dwellings built over pits in Saghalin, but not much dependence can be placed upon his descriptions, as he did not enter the houses.

Ancient Japanese tombs and burial mounds. By Romyn Hitchcock, Washington, D. C.

[ABSTRACT.]

The most ancient form of burial in Japan was in a simple mound of earth, perhaps in a wooden coffin. Cave burial was also practised, the caves being hewn out of solid rock, and the dead placed in stone or earthen coffins. After this came mounds of two forms, one with stone chambers with long entrance passages, constructed by piling up large stones and covering them with earth, the other large double mounds surrounded by one or two moats.

The latter are quite common in Yamato province, where many of the early emperors are buried in such tombs. Their form is like a long mound, of perhaps one hundred feet in height, running north and south, with a slight depression near the middle and constricted at the sides. The south end is square, the north end rounded in plan. Interment was near the top of the north end.

The sides are terraced and the soil kept in position by concentric rows of clay cylinders, about two feet in length by eight inches or a foot in diameter.

In early times, it was a custom to bury the persons in attendance upon a high officer upright around his grave. As they were buried alive up to the neck, they suffered greatly until relieved by death. One of the early emperors desired to stop this custom and called his councillors together that they might devise a plan for suppressing it. One of them advised that clay figures should be made to represent men and horses, and that these should be buried instead of living persons. The suggestion met with favor, and now very strange figures are occasionally, though rarely, found about the tombs which were buried instead of human sacrifices.

The Dokhmas or Parsee towers of Silence. By Mrs. Romyn Hitchcock, Washington, D. C.

[ABSTRACT.]

An account of the Parsee Dokhmas at Bombay, with notices of the origin of the custom of exposing the dead to be eaten by beasts and vultures. The Parsees were expelled from Persia by the persecutions of the Mohammedans, and finally established themselves in Bombay, where they now number about 72,000, constituting an influential and wealthy portion of the community. They retain their old customs and observances. The paper was illustrated by original photographs and drawings.

ON THE EVOLUTION OF ORNAMENT — AN AMERICAN LESSON. By W. H. HOLMES, U. S. Bureau of Ethnology, Washington, D. C.

[ABSTRACT.]

THE evolution of ornament is a topic of interest to all men. American art furnishes a large body of data bearing upon this subject which deserves very careful consideration. This is especially true since the primitive character of our aboriginal art renders its use in the study of questions of evolution comparatively easy. It is intended in this paper to dwell only upon the development of certain well-known conventional designs. Two arts, the textile and ceramic, are found to be almost exclusively concerned. Elements of decoration enter these two arts in two great currents one of which carries mechanical and the other graphic elements. When once within the realm of decoration these elements are subject to the action of two great forces, the æsthetic desires of the mind, and the technical or mechanical agencies of the art.

The two leading questions that arise are, 1st, how do the mechanical elements inherent in the arts develop into certain definite highly constituted forms, and 2nd, what part do nature derived elements take in the same work?

It appears that, granting the moving force to be the æsthetic desires of men, the formative agencies pertain to the art, its material processes, etc., and are for the most part technical in nature. In the textile art these agencies are very pronounced and it is easily shown that through their action all forms, mechanical and graphic, tend to assume the linear geometric character. Arts of more or less graphic or plastic nature act in their own ways to produce corresponding results.

It is seen that strong resistance to the tendency of the arts to reduce all graphic forms to the purely geometric is offered by the association of ideas with the delineations. We have here the conservative force of art, which in order to express ideas clearly holds tenaciously to the first form of expression, the graphic.

CONTENTS OF CHILDREN'S MINDS. By HARLAN H. BALLARD, President of the Agassiz Association, Pittsfield, Mass.

[ABSTRACT.]

1. GERMAN students have tested children by carefully prepared series of questions designed to disclose: *a*, their processes of thought; *b*, the amount of their knowledge.

2. Result of putting the questions used by the German philosophers, in examining German children of seven years, to my own son, aged five years, nine months and eleven days. His exact replies.

3. Additional questions designed to test his powers and habits of independent observation, memory and general information, with his replies.

4. Illustrations of reasoning ability in a child of five.

SEEGA, AN EGYPTIAN GAME. By DR. H. CARRINGTON BOLTON, New York, N. Y.

[ABSTRACT.]

THE author learned the game of Seega from Bedouins in the Desert of Sinai. It is similar to draughts yet has novel principles and is a clever game of skill. The author illustrated his paper by a blackboard diagram.

THE AFRICAN IN CANADA. By JAMES CLELAND HAMILTON, LL.B., Toronto, Ont., Can.

[ABSTRACT.]

THE introduction referred to the various races found in Canada, but of all these, whether native or immigrant, it was claimed that when the history of the last fifty years is written, none will be found more interesting, as a class and as parcel of the state, than the colored population.

Under this head were included all having African blood, pure or mixed, in their veins.

In Canada the black refugee was surrounded by an active white population, had seldom any capital but his strong right arm, and had to lay his plans so as to rival the white man and "take his bread out of the stump." It was shown that no such contest had, in any other place before American Emancipation, been undertaken by the African race.

The speaker stated as his object, to present such an account of the course of this people as from observation and documents, but especially from personal enquiry, he had been able to gather during a residence of some thirty years in Toronto.

At the beginning of this period, in 1860, there were about 40,000 colored people in Upper Canada, few being found in the other provinces.

Reference was then made to proceedings at conventions of people of color, in the United States, so far back as 1831, in which the prospects of the west coast of Africa and the West Indies as places for their immigration were discussed, but these were overruled in favor of Canada West. At this time several thousands of fugitives from slavery had settled in our province. The Rev. Isaac J. Rice from Ohio and Rev. Hiram Wilson came to work among them and were aided by Quakers and other philanthropic Americans. After them the Rev. William King followed bringing from Louisiana his slaves, fifteen in number, whom he freed and settled in the township of Raleigh on Lake Erie near the town of Chatham. An Association styled in honor of the then governor of Canada, the "Elgin settlement" was formed August 10, 1850. A tract of land containing nine thousand acres of good soil was procured. The place was called Buxton, in honor of Sir T. F. Buxton, and here began the work of colonizing and making homes for the fugitives on an extensive scale. The land was leased and finally sold only to colored people and on such easy terms of payment

as made it practicable for them to purchase. Mr. King himself lived for twenty-five years in the settlement as agent of the Association, missionary and teacher, and has had the satisfaction of seeing the land all sold, cleared and occupied by his people. He has, in late years, lived in Chatham, but seems satisfied with the success of his self-denying efforts and in a communication to the essayist stated "the Elgin settlement has accomplished what we intended, which was to show by a practical demonstration that the colored man when placed in favorable circumstances was able and willing to support himself, and although the soil and climate were not the same as those which they left, yet these people have done as well as any white settlement in the province under the like circumstances." Some of the young men educated at Buxton have been elected to civic offices in the United States. One was James Rapier, a member of Congress from Montgomery, Alabama, during General Grant's administration. "Others are," says Mr. King, "teachers, preachers, doctors and lawyers." "Most of the educated colored people," he also states, "left Canada during the war and very few are coming to it now."[1] The writer then gave instances of *Slaves* and *Slave Law* in Canada and an account of Solicitor General Gray and the Baker family as follows:—

"The propriety of importing African slaves as an economic measure was considered in the Council of Quebec as early as 1688 when the Attorney General visited Paris and urged upon the King the expediency of importing negroes as a remedy for the scarcity and dearness of labor. The King consented but advised caution owing to the severity of the climate. A few slaves were brought in but the system never flourished." (Parkman's Old Regime in Canada, p. 388.)

Slaves were made also of Pawnee Indian captives, but their dislike of steady employment and propensity to escape to the woods impaired their value, says the same authority.

Court records show traces of both negro and Pawnee slavery in the Lower province till February 18, 1800, when the court of King's Bench at Montreal discharged the negro *Robin* from custody, and this decision being acquiesced in, practically ended the system there. This and the accident of climate saved Quebec from future servile trouble. The province now called Ontario was but sparsely inhabited. Slavery did exist to a limited extent in Upper Canada, till 1793, when an act was passed by the infant parliament of that Province, at the town of Newark, now Niagara, prohibiting the importing of slaves, and declaring that no negro or other person brought into Upper Canada should be thenceforth subject to the condition of a slave.

It will be noticed that in this our Province had the honor to precede the mother country, which passed the act emancipating slaves in all her colonies in 1833. It is but fair to note that Pennsylvania and Rhode Island

[1] In 1863, Messrs. R. D. Owen, James McKay and S. G. Howe, members of the "American Freedmen's Commission," visited Buxton, made careful inquiry and reported as to the condition of the colored people there. Their report helped to add the 14th amendment to the U. S. Constitution.

had shown us an example, emancipation having been decreed in those states in 1780. Ours was a rare little Parliament that so honored itself, sitting sometimes in its chamber at Navy Hall and then as the day grew sultry, adjourning to the shade of a spreading tree, as Dr. Scadding describes the scene. There were but a baker's dozen of them in all, seven crown appointed councilors and five commoners. Mr. McDonell of Glengary was the speaker.

The act then passed also made provision for the gradual emancipation of the three or four hundred slaves then in the Province. Down to the year 1833, when the imperial act referred to took effect, some of these old slaves were still to be seen in Canada, even as such were to be found within very recent years round the old homesteads of New Jersey.

Dr. Scadding has collected in "Toronto of Old" several references to slavery in this province as practised early in this century; among those offering to deal in the human article being the governor, Peter Russell, who in 1806 advertised for sale a black woman Peggy, and her son Jupiter.

Slave advertisements were then common in the Quebec Gazette. In the western part of this province the great Indian Chief Brant, or Thyendenaga, had African slaves, it is said, but I have been unable to verify this historically. He was a contemporary of Governor Russell. Our Indians were too nomadic to make African slavery profitable with them. It was, in fact, of most rare occurrence in the northern tribes, while in the south blacks tilled the soil of Cherokee and Choctaw farmers.

The amiable characteristics, forming the pleasant part of the history of slavery on this continent, were so exhibited, in the life of the late Solicitor General of Upper Canada, Mr. Robert Isaac Dey Gray, that I am tempted to give some details of his career not generally known.

He was son of Colonel James Gray, who was a Highland Scotchman of good family. Mr. Gray lived on the north side of Wellington Street in Toronto, then Little York. As part of his family he had a colored slave woman Dorin, or Dorinda, Baker and her children, among them her sons John and Simon. A sad fate awaited him and Simon his gay young body servant. A court was ordered for trial of an Indian murderer, at Presque Isle in county of Northumberland, then Newcastle district. This being before the use of steam, Judge Cochrane, the Solicitor General and his servant, with the sheriff, embarked on the government schooner 'Speedy,' Captain Paxton, for the place of venue. A gale came on, all went down and were lost on the night of 7th October, 1804. By his will, made August 27, 1803, Mr. Gray "manumits and discharges from the state of slavery in which she is now his faithful black woman servant Dorinda" and gives her and all her children their freedom. To John and Simon he also left two hundred acres of land, and directed that twelve hundred pounds should be set apart and the interest applied to the maintenance of the family.

I am indebted to Judge Pringle of Cornwall, Ont., a relative of the Gray family, for the extract of a letter written by Mr. Gray to his cousin Catherine Valentine at Kingston, Feb. 16, 1804. After giving an account of his

endeavors to recover property abandoned by his father, who had been a major in the first Battalion, King's Royal regiment of New York, he states "I saw some of our old friends while in the States; none was I more happy to meet than Lavine, Dorin's mother. She was living in a tavern with a woman by the name of Bromley. I immediately employed a friend to negotiate for the purchase of her. He did so stating that I wished to buy her freedom, in consequence of which the man readily complied with my wish and, although he declared she was worth to him £100, he gave her to me for $50. When I saw her, she was overjoyed and appeared as happy as any person could be, at the idea of seeing her child Dorin, and her children once more, with whom if Dorin wishes she will willingly spend the remainder of her days. I could not avoid doing this act. The opportunity had been thrown in my way by Providence and I could not resist it. I saw old Cato, Lavine's father, at Newark, while I was at Colonel Ogden's. He is living with Mrs. Governeur, is well taken care of and, blind, poor old fellow, came to *feel* me for he could not see me. He asked affectionately after the family."

John Baker survived the others of his mother's family and died in Cornwall, 1871, at a patriarchal age. For the last nine years of his life he had a pension from the English government for services in the war of 1812. On August 11, 1868, I met John Baker and got the story of his life, which is redolent of old times and customs and is that of one of the last Canadians born in bond service. I give it as he told it. First let me picture him as a very dark mulatto of amiable disposition and countenance, hobbling from rheumatism and laying down his wood-saw as I asked him to sit down on a box in a grocery, and handed him a plug of his favorite weed. "I was born at Quebec, brought up at Gray's Creek. My mother Dorinda, was from Guinea, my father was a Dutchman, probably a Hessian soldier. Old Colonel Gray, father of 'Solisary Gray,' was colonel of a Scotch regiment and wore kilts and married in the United States. I came to Gray's Creek near Cornwall, when a boy, and Gray's son was then also a lad. I lived here with Mr. Farrand who used to go on horseback and had his trunk strapped on my back. He rode like a Tartar, and the trunk used to knock on my back. Young Gray was the only child of the Colonel and went to Parliament thirteen years running. The Colonel was strict and sharp and put deerskin shirts and jackets on me, and gave me a good many whippings. Simon was older than me, and was 'Solisary' Gray's body servant. I lived two years in Toronto, or Little York, in a large white house, north of the boat landing. The people was proud and grand them days. Simon was dressed finer than his master with a beaver hat and gold watch. Governor Hunter ordered the party to go to the trial in the 'Speedy.' He was a severe old man and wore leather breeches. In one pocket he carried tobacco, in the other snuff and when giving his orders he would take a handful of snuff, and it would fall over his fine ruffled shirt,—fine, I tell you, no mistake, and silver buckles to his shoes. Never saw him with a boot on. Solisary Gray when he went off last, told me to look after the place and he would be back in a day or two. They started between four and five in the evening

and we heard of the loss next morning from the brig 'Toronto.' There were in York about twenty houses then.

"After that I went to Judge Powell's. A recruiting agent came along, and I listed. Judge Powell paid the smart for me seven times. I said, 'thank you, sir,' and I listed again. I served three years in New Brunswick. Col. Drummond was then colonel and Col. Moody was lieutenant colonel. Moodie who was shot on Yonge street and Drummond scaling ladders at Fort Erie. I was at Waterloo in the 104th Regiment under Col. Halkett. We chased Napoleon, who rode hard and jumped the ditches. We marched over our shoes in blood. I saw Wellington, General Brock and many other great men in my time. We came back to Canada and got our discharge. I was a wild, foolish boy. The Lord will be with us all by and by, I hope. Good-bye."

Mr. Hamilton next discussed the cause celèbre of John Anderson the fugitive slave, arrested in Toronto under the Ashburton Treaty in April, 1860, for killing one Diggs in Missouri, when escaping. He was released by the court of common pleas on a technicality, after much legal argument and public discussion and excitement.

Professor Aytoun's story of Haman S. Walker, as related in "Blackwood," thirty years ago, and again in the novel "Norman Sinclair," was referred to. Walker is represented as a villain who, pretending to be a suffering abolitionist, came to Toronto, ingratiated himself with the colored people, married the daughter of a well-known livery-stable keeper, took her south, secured a bill of sale of her father, from his former master, sold his wife, and when the father came to Charleston to redeem his daughter, he found himself the chattel of his worthy son-in-law, and had, as is represented, to redeem both. This witty tale the essayist declared he had found to be entirely untrue. The professor was the victim of a cruel hoax. The young woman referred to married a colored man and removed to Milwaukee.

A résumé of two interesting discussions in the Canadian parliament, having reference to imposing a capitation tax on colored immigrants, was then given. Mr. Larwell was mover in the lower house, and Col. Prince in the other. Both motions were negatived. During one of these an amusing incident occurred. The gas went out. A member rose and solemnly said, "Mr. Speaker, I move that light be given on this dark subject." An account was given of instances of loyalty of this race to their adopted land, and of their refusal to accept inducements to go to Hayti, Trinidad and elsewhere. Some personal references were then made to the colored people in Toronto, Hamilton and elsewhere in the province. The Nestor of Toronto is John Tinsley who came from Richmond, Va., and claims to have completed his one hundred and sixth year on last fourth of July. He is a quadroon; his father Captain Samuel Tinsley served in the Revolutionary and Georgia Indian wars. He is an interesting old man, and has a store of knowledge of Old Virginia days.

The history of Josiah Henson, commonly known as the original "Uncle Tom," was given. He was a man of much natural ability, gathered his people around him at Dresden, Ont., went to England and New England,

and lectured to great audiences who, as did Lord Shaftsbury, Earl Russell, Archbishop Tait and others, aided him in his enterprise. The Queen asked him, "Have you any family?" "I have ten children, forty-four grandchildren and nine great grandchildren, your majesty," I answered. "Why," she exclaimed, "you are a patriarch." The archbishop asked him, "At what university, sir, did you graduate?" "I graduated, your grace, at the university of adversity." "The university of adversity," said he, looking up in astonishment, "where is that?" I saw his surprise and explained my meaning.

The English papers made him famous as "Uncle Tom." Interesting reminiscences of the life and labors of this remarkable man were then given. He was born a slave in Charles county, Virginia, June 15, 1789, and died in Dresden, Ontario, on May 5, 1883. As a result of his labors mainly, the Wilberforce Institute for the education of colored youth was founded at Chatham, where it is still doing good work. The writer closed as follows:—It has been variously estimated that of our colored citizens those of pure blood were between one-fourth and one-third of the whole number, the others being mulattoes or of the other mixed classes. About half of the adults were fugitives from the south, and these were esteemed by Mr. King as the best class, as they possessed that activity and manliness by which they secured freedom. Besides a difference in the shades of color we should also remember that the negroes found in Canada are descendants of various African tribes, some of which were intelligent, vigorous, and full of martial spirit, while others were of a lower calibre, some even signifying with a few almost inarticulate expressions, in their native wilds, all the desires which their rude life called for, or gave rise to. Some of those originating from the former African stock are esteemed equal in natural intelligence to whites of like station and opportunities, while the latter could not be raised by any educational process to the same level.

From this diversity of origin probably arise, to a great extent, contradictory opinions regarding the capacities of the race. Some who draw their conclusions from their experience among the inferior, judge that all the tribes, and their American descendants, are equally degraded while others are as much led astray in an opposite direction, by regarding only the superior classes.

The part of Ontario occupied by these people is rich in soil and has a climate similar to that of Michigan, yet the general opinion I found current, both among themselves and others conversant with the subject, is that it is not the country best adapted to their natural requirements. They are specially liable to phthisical diseases. I should remark, however, that doctors disagree on this point, and I speak with diffidence but think the weight of authority will be found as just expressed. There are many persons of advanced age among them. Many of the colored men, who were found in our gaols, were not of the class of fugitive emigrants proper, but of the criminal ranks, who evaded the penalty of crimes committed in the states by escaping across the border. The statistics from penitentiaries

and prisons, especially during the period before emancipation, must be regarded with proper allowance for these circumstances. A friend, who has been for many years a county crown attorney, and has had much experience of this people, condensed his views thus:—"There was a reaction after the enforced labor of slavery. The black folks regarded with suspicion any effort to guide them politically or morally. They were not thrifty and did not lay up much for the future, as a rule; but improved in this, as they learned necessity from experience. They were easily led astray by designing men, among whom were many cunning half-white fellows. The offences with which they were charged were generally the result of weakness, rather than vicious disposition, 'minor crimes, seldom felonies."

The wonderful changes in the political and social aspect of the land, whence they fled, again pointed these people to that as the land of promise for them and their children. As a summary of their views before these changes, and irrespective of them, allow me in conclusion to read a short extract from a resolution passed at a colored convention held in Toronto in September, 1851.

"We feel grateful as a people to her Britannic Majesty's just and powerful government for the protection afforded us, and we are fully persuaded, from the known fertility of the soil and salubrity of climate of the milder regions of Canada West that this is by far the most desirable place of resort for the colored population to be found on the American continent.'"

I have now given an imperfect, but I trust, an accurate view of the career of this race in Canada. I claim for our Dominion, but especially for this Ontario province, that she has in her schools and colleges, in her legislatures and in her courts, in heart and in hand, been the good Samaritan to the sons of Ham in their days of trouble. But it is not in any spirit of boasting, however moderate or patriotic, that I would close this account of our colored fellow citizens and their career in Canada.

This race must have a great future on this continent, though it is expected that as Africa is opened up, many will return to the land of their forefathers. The Indians become Metes, but the black man becomes blacker, more distinct and more African. He daily grows in numbers, in knowledge and in power. The Canadian problem has worked out happily. We have had no Pharaoh to distress our land of Goshen nor have plagues disturbed us. The former involuntary exodus to the north has been succeeded by a voluntary interchange of people and products over the bridge of peace and freedom which unites our countries.

The greater problem looms before you. We do not fear the result, if knowledge and science do their part.

Whatever be our political future, we of the north must share, and bear, with you of the south, one grave united interest, in the working out of this great racial problem in the social destiny of the continent. We say in the words of the pious Æneas:—

"Una salus ambobus erit."

ARTIFICIAL LANGUAGES. By Prof. DAVID R. KEYS, University College, Toronto, Ont.

[ABSTRACT.]

THE scientific value of an artificial language consists not merely in its usefulness to investigators but in the light that the adoption of such a language would throw upon the old question as to whether language exists as a natural growth or as a convention.

An historical sketch of the attempts to create an artificial language, with special reference to the early efforts of Leibnitz and Wilkins. The merits and defects of modern inventions such as those of Schleyer (Volapük) and Esperanto, of which the latter would be preferable on account of its simpler grammar and more practical character.

Finally a doubt was expressed whether it was not better that the scientific worker should study two or three modern languages as the best training in the comparative method which is the basis of all modern research.

RESULTS OF EXPLORATIONS OF AND ABOUT THE SERPENT MOUND OF ADAMS CO., OHIO (In aid of which a grant was made by the Association). By Prof. F. W. PUTNAM, Peabody Museum, Cambridge, Mass. [To be printed in full in the Century Magazine, April, 1890.]

DISCOVERY OF A NEW LINGUISTIC FAMILY IN CALIFORNIA. By H. W. HENSHAW, Bureau of Ethnology, Washington, D. C.

GOVERNMENT OF THE SIX NATIONS. By O-JI-JA-TEK-HA, Toronto, Ont.

THE HURON IROQUOIS OF THE ST. LAWRENCE AND THE LAKE REGION. By Sir DANIEL WILSON, Toronto, Ont.

THE ACCADS. THE EARLIEST BABYLONIANS. WHAT WAS THEIR DESCENT? WHAT GREAT MODERN NATION IS DERIVED FROM THEM? By Miss VIRGINIA K. BOWERS, Newport, Ky.

SECTION I.

ECONOMIC SCIENCE AND STATISTICS.

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ADDRESS

BY

CHARLES S. HILL,

VICE PRESIDENT, SECTION I.

ECONOMIC AND SOCIOLOGIC RELATIONS OF THE CANADIAN STATES AND THE UNITED STATES, PROSPECTIVELY CONSIDERED.

"What God hath joined together" — no man can rend asunder.

JOINED by natural conditions of creation, by ties of consanguinity and language, by bans of matrimony and posterity, these two peoples, assembled here to-day, of the Canadian States and the United States, must eventually be one and inseparable — inevitably.

Our relations with the Canadian people are closer than our relations with those of any of our sister American Republics, although of similar form of government, because of the difference in the language of the latter.

The science of God in nature is far grander than the science of man in art.

In His infinite wisdom our topographic conditions are one and inseparable.

By His divine will our language of communication is one and the same, and the Christian cross is our religious emblem of one faith, whether of the Anglican, Roman or Grecian branch of the church.

These are the unifying elements which render our destiny one as a people and one in government.

These conditions are *de facto* and unchangeable, therefore they need no consideration.

Our economic and sociologic relations are problematic, and an analysis of the prospective conditions thereof can but be of benefit and interest in anticipation of union or not, but the union of these two peoples in one government eventually is as certain as the union of territory is now definite and unalterable.

Two committees of the United States Congress are already in the field studying this problem from a political point of view, and that a lively and important discussion will take place at the coming session of Congress in Washington next winter is very certain.

Grave and serious may be the immediate results of the coming consideration as an international question, in view of the remarkable existing and rapidly developing conditions that are assuming such complicated features, but the ultimate result will be annexation and consolidation.

In view of the existing conditions on the one hand and the prospective conditions on the other, there seems to be no more pertinent and important an economic problem for consideration before this Section to-day.

I shall not pretend to analyze each specific subject of these conditions in cause and result, but merely open a discussion as to the economic measures and sociologic benefits to be attained in the future; nor shall I burden you with statistical data more than in a few tabulations, for such are familiar to you all.

The many distinguished economists of scientific study and world-renowned fame attending this convention, and who have recorded special papers to be presented to you during our sessions, will more ably interest and inform you.

When we compare our natural conditions with those of the many peoples of the Old World, what a mighty contrast is presented, and what a volume of thought is suggested.

On this new continent the English tongue has sounded over lakes, reëchoed over the plains, and reverberated over seven millions square miles, from ocean to ocean, obliterating the dialect of hundreds of thousands of immigrants yearly and silencing in extermination the tongues of the aborigines.

On the old continent we find different peoples and hear different tongues within the short distance of every few hundred thousand square miles. From the Hebrides of Europe to the Himalayas of Asia, to the far north of Siberia, we listen to a confusion of languages, find a variety of religions and religious superstitions, and we see that even rivers, as well as

"Mountains, interposed, make enemies of nations
That else, like kindred drops, have mingled into one."

With us a continent is being developed into homogeneity by the inspiring and subduing force of the English language, and what is being done on this continent is also being done the world over, and by the same cause—the unification of the English-speaking people.

OUR ECONOMIC RELATIONS.

Of the United States, what can be said?

Endowed with wonderful and unexampled prosperity that have blessed us for a century of years, through great vicissitudes of political circumstances, in peace and in war; in the possession of a soil that has yielded far more than ample harvest for our wants of every character; in the knowledge of owning vast undeveloped mineral resources of untold and inestimable wealth; under an established economic policy of government laid down by our fathers, who framed our Constitution and who enjoined upon us to follow their policy, and which has only twice been interrupted by indiscreet and ruinous political passion in legislation—it appears natural that our neighbors and friends of the Dominion of Canada should be blessed with like possession of riches in geological, agricultural, and industrial development, at present denied them by legislative limitation and requirements, not necessary to dwell upon here.

It seems to us, blest with such past and prospective prosperity, singular that you of Canada should not be unanimously anxious to become united to such a people and form of government.

And of Canada, what?

The etymologic significance of the Indian *Kannatha* is no longer applicable to the Dominion of these great Provinces; *La Nouvelle France* has long since lost its significance, if not its identity.

Relatively in resources the present Canada is as wonderfully wealthy, as rich in fertility of soil, and as progressive in enterprise and genius as is the United States. During the last decade the Dominion has made more rapid strides in the utilization of her possessions and opportunities than ever before.

The vast area of the Dominion offers a supply of several natural products in greater abundance than the United States, and even some which we do not possess.

With a climate varied but little from our own, except in the most

northern part, there appears in the near future a grand prospect for immense settlement and great prosperity.

But the historic phrase of *British* North America is even now a misnomer and will soon become obsolete.

There are "*Three Americas*"— North, Central and South. Of the first, from the Arctic to the Gulf there can be but one people eventually, of one language and of one government.

The similitude of Republican government between the United States and Central America is a tie of strong sympathy, but language and consanguinity bind us closer to you of Canada.

It has been truly said that the ties of blood were stronger than water, but it may be added that ties of language, religion and blood must, sooner or later, blend us, now two peoples, into one.

UNIVERSAL CONDITIONS.

Let us then consider the conditions and prospects that we find before us.

A commercial union is impracticable, for there must first be universality in political government, as well as in economic and sociologic conditions and national assimilation.

It would be preposterous to establish a free-trade policy with Canada and preserve a protection policy with England. The side-door entrance would be used exclusively for commercial intercourse with Great Britain and the trade of our Atlantic and Pacific seaport cities would be ruined and the prosperity that our merchants have enjoyed would be known no more forever. The employment which they now distribute to the poorer classes of those thickly-settled and thriving cities would be not only interrupted, but destroyed. Loss of wages, idleness, discontent and strife, would result as surely as such a basis of intercourse should be established with a people that belonged to and were under the government of a European nation. Were you of Canada an independent people a commercial union would be a very different matter for consideration.

But as long as the Canadian people are under the control of the British government, which now rules the seas and the commerce of the world, to open such a side door of traffic would be cutting the artery of our industry and bleeding of our workmen to death.

A commercial union with Canada would, of course, be practically a commercial union or a free-trade traffic with Great Britain.

As well might we establish the union direct and better that we declare free trade to the world.

Assimilation of political interests must come before a "commercial union" is possible.

How shall it come? The United States cannot court it or tender a protectorate to the Dominion. It would be directly contrary to our national policy to acquire territory by means of aggression.

Canada must be the suitor. She must make her peace with her home government and obtain the consent of mother England before entering into a matrimonial alliance with ourselves. Whether the United States must assume the debt of Canada or pay a consideration in money will be a question of agreement.

GOVERNMENT.

Autocracy, plutocracy, democracy, which?

For one hundred years the people of Canada have failed to become assimilated even in themselves.

For one hundred years the people of the United States have been banded as one, except during the brief period of political passion—in which the flames and fury of prejudice were fanned by influences from abroad — and by ignorance of true politico-economic principles at home; but the dark cloud of strife and difference has passed, and now, more purified in love and stronger in reason for the sad lesson learned, we are *one*, "now and forever."

Why, then, this great contrast in similitude of conditions existing between two people, side by side?

It is because of the difference in form of government.

Ex-President White, of Cornell University says that—

> "The first requisite to a good government is to educate the great mass of citizens to the point of grasping simple political questions,"

and so it is emphatically.

Between autocracy and democracy there seems to have sprung up a fear of plutocracy, or rule of wealth, in our remarkably prosperous country, but that fear can be calmed by the reflection that in the country where the poor man has an equal chance with the rich man—provided that industry and integrity are equally prominent—plutocracy is impossible.

The Premier of Canada, Sir John Macdonald, is, of course, in his earnest loyalty to England, a zealous monarchist, and has no taste for the agitation about the question of annexation of his people to ours, for he well knows that it could only be done by renouncing the autocracy of the royal family and assuming the democracy of our people.

It is to his wisdom and foresight, however, that Canada owes her progressiveness and advancement in the last ten years; but it would be only fatality that caused him to realize that his skilful statesmanship and economic judgment only hastened the accomplishment of annexation to our people's government—the last result that he desired.

Perhaps the most witty observation upon this subject has come from the Hon. Mr. Chapleau, Canadian Secretary of State, at a dinner in Montreal recently, viz.: that, while he did not wish to disparage the United States he would say that if they were to annex themselves to Canada it would be good for them. But he erred very much in the prospective view when he added that "these movements towards the United States mean only one thing—destruction to Canadian industries," for such has not been the experience of any state or territory of our Union.

Mr. Erastus Wiman, who is well informed concerning the interests and circumstances governing both peoples, says he regarded it as

> "Unfortunate that the whole continent was not included in the American Revolution. Only Great Britain's liberal policy, which she exercises toward her vast western colony, and which she learned to be imperative for peace one hundred years ago, has made possible the continued colonial existence of Canada. The Dominion is to-day intensely loyal to the English government, because of the extended influence of the Orangemen, who resist the encroachments alike of Americanism and Catholicism; because of the six hundred and fifty millions of dollars of British capital invested in Canadian enterprises; because of the influx of British emigration, which deliberately chooses British land in which to live and because of the undesirable character of the exiles who seek in Canada immunity from punishment for crime committed in the United States."

To take a view from another side, which is the only just means of learning the true sentiment of a people, let us listen to the expression of the Premier of the province of Quebec, the Hon. Honoré Mercier, who says that "*Quebec is a British colony only in name.*"

He adds—

"The aspirations and ideals of her people are as un-British as they well can be, and their hearts beat for France and not for Britain. It is not the record of Saxon achievements that stirs their pulses.

"With two races that have spilled each other's blood on half a hundred fields from the days of Agincourt down to Waterloo, Canadian statesmen are trying to build up a nation, and after more than a century of intermingling the materials are found to be as incongruous and as unmixable as they were on the day when the *fleur-de-lys* bowed its splendors before the valor of Wolfe under the walls of Quebec. Who will say that the task is not a colossal one? It begins to look as if it were a hopeless one."

Premier Mercier presents the point of consideration forcibly for reflection upon the contrast between the people of Canada and of the United States:

"How comes it, Americans may ask, that Canada has failed to assimilate the French Canadians, when the states have assimilated and made American citizens of the people of every clime on the globe?"

Here is strikingly impressed the influence upon the spirit of the people under an autocratic in distinction from those under a democratic form of government.

UNRESTRICTED TRADE.

Do reciprocity treaties reciprocate?

This question requires careful consideration and reflection, much more than it is possible to present to you in an address this evening, and certainly much more than seems to be given by the major part of political representatives of either nation.

Reciprocity treaties are generally economic and sociologic, and are termed "*Commercial and Amity Treaties.*"

The former comes under this division of my argument because it is a contribution to or deduction from the public revenue of a people and should be framed by a practical body of economists and business men, not by politicians. The latter comes under the following division because it is a diplomatic tie governing the sociologic conditions of one nation with another, and may be, perhaps, more happily drafted by the genial warm-hearted, and theoretical diplomatist than by the cold, hard-headed, calculating, and money-making merchant.

Reciprocal treaties are good enough so far as they protect against

discriminations of trade tricks in the ports of two countries, but for growing countries like the United States and Canada to be circumscribed and handicapped by bodies of diplomatic obligation against economic interests and development is absurd. For instance, we find ourselves, by our infantile treaty of 1818 with England, which we have outgrown, ridiculously appearing as an overgrown man wearing the short clothes of boyhood, mortified and smarting yearly under the obligation to our parent country, which is now infinitely the smaller, to the disparagement of our commercial interests of the breaking of good faith.

To show this absurdity authoritatively, however, and the danger of short-sighted, so-called reciprocity treaties, I quote from a report of the Committee on Commerce of the United States House of Representatives, May 28, 1842, made through its chairman, Hon. John P. Kennedy, of Maryland, a statesman and economist. That Report, No. 835, 27th Congress, 2d session, page 27, says:

"The aim of our Government has been to establish reciprocity in trade.

* * * * *

"It seems to have been imagined that reciprocity consisted in equal privileges of importation and exportation in our own vessels and the vessels of the nation with which we established these relations; that the greater the scope given to these privileges of import and export, the nearer the approach to perfect reciprocity."

This Committee of Congress did not make a superficial research into the cause of civil results in our commercial conditions, but thoroughly cut to the germ of the disease by analytical dissection, as will be seen by reference to that remarkable document:

"Our commerce has been proffered to the world upon terms dictated by the most friendly disposition, and with a sincere desire to give the utmost scope to the expansion of commercial adventure." * * *

"Our citizens have acquiesced for years in these arrangements, under the specious delusion that, as the system professed to be one of *reciprocal* advantage, we have gained by it reciprocal freedom of trade."

The Report adds with severe comment:

"The Committee have already pointed out the *fruits* of this reciprocity."

It is of interest here to examine the record of our treaties so as to place correctly in the mind the character and date of each that we have made with nations professedly reciprocating the benefits anticipated and to judge of the results.

TREATIES, OBSOLETE AND EXISTING.

The first commercial treaty of our country ever made was with France, in 1778, but it was afterward broken by that country in its principles of amity and economic relations, which caused an interruption of our navigation and commerce upon the Atlantic Ocean.

The order and date of these treaties under the old Government were, viz.:

Old Confederation.

1778, Feb. 6	France	Amity and commerce.
1782, Oct. 8	Netherlands	Amity and commerce.
1782, Oct. 8	Netherlands	Recaptured vessels.
1783, Jan. 20	Great Britain	Armistice.
1783, Apr. 3	Sweden	Amity and commerce.
1783, Sept. 3	Great Britain	Peace.
1785, July 9, 28; Aug. 5, Sept. 10	Prussia	Amity and commerce.
1788, Nov. 14	France	Consular.

These were all the treaties of the original Government, made from the date of rebellion against British Commercial Taxation to the reorganization under the title of United States of America, March 4, 1789.

Under the reorganized Government our first treaty with Great Britain was of Peace, Amity, and Commerce, dated November 19, 1794. It was the first treaty under the Constitution of the United States, and signed by "Grenville" and John Jay, to which was afterward appended an additional and an explanatory article signed by "Bond" and Timothy Pickering. This treaty, however, although fully detailed specifically, was not in force long, but supplemented, as will be here shown, by sharp diplomacy to the disadvantage of our people from the year 1815 to the present day.

The schedule of existing commercial treaties is as follows:

Reciprocal Commercial Treaties of the United States existing at present (alphabetically arranged).

Nation.	Date of Treaty.	Nation.	Date of Treaty.
Argentine Confederation	July 27, 1853	Corea	June 4, 1883
Austria-Hungary	Aug. 27, 1829	Costa Rica	July 10, 1851
Belgium	Mar. 8, 1875	Denmark	April 26, 1826
Bolivia	May 13, 1858	Dominican Republic	Feb. 8, 1867
Brazil	Dec. 12, 1828	Equador	June 13, 1839
Chili	May 16, 1832	France	Sept. 30, 1800
China	Nov. 17, 1880	Germany	July 3, 1815

Nation.	Date of Treaty.
Great Britain	July 3, 1815
Supplemented	Oct. 20, 1818
Renewed	Aug. 6, 1827
Greece	Dec. 10–22, 1837
Guatemala	Mar. 3, 1849
Hanover	June 10, 1846
Hanseatic Republics	Dec. 20, 1827
Hawaiian Islands	Jan. 30, 1875
Hayti	Nov. 3, 1864
Honduras	July 4, 1864
Italy	Feb. 26, 1871
Japan	July 25, 1878
Liberia	Oct. 21, 1862
Madagascar	Mar. 13, 1883
Mexico	Jan. 20, 1883
Morocco	Sept. 16, 1836
Muscat	Sept. 21, 1833
Netherlands	Oct. 8, 1782
Supplemented	Jan. 19, 1839
Renewed	Aug. 26, 1852
New Granada	Dec. 12, 1846
Nicaragua	June 21, 1867
Norway	July 4, 1827
Ottoman Empire	Feb. 25, 1862
Paraguay	Feb. 4, 1859
Persia	Dec. 13, 1856
Peru	Sept. 6, 1870
Portugal	Aug. 26, 1840
Prussia	May 1, 1828
Russia	Dec. 1–13, 1832
Salvador	Dec. 6, 1870
Samoa	Jan. 17, 1878
Siam	Dec. 17–31, 1876
Spain	July 22, 1819
Sweden (see also Norway)	July 24, 1827
Swiss Confederation	Nov. 25, 1850
Tripoli	June 4, 1805
Tunis	July 24, 1824
Turkey (see Ottoman Empire).	
Venezuela	Aug 27, 1860

This list includes only those of Commerce and Navigation and does not include Treaties of Peace and Amity.

How far these Reciprocal Treaties have really effected a reciprocation and benefit to our trade—even where most effective—is a question to which we should give careful examination, and it is the duty of every business man to consider the same, as they deeply affect his financial interest.

Since the adoption of our Constitution *one hundred and thirty* Reciprocal *Commercial* Treaties have been made valid, of which *seventy-seven have become obsolete*, and the fifty, recorded above, remain in force. These Reciprocity treaties have been of varied purport, viz.: "Consular," "favored nation privileges," "real estate," "personal property," "privileges to vessels," "merchants," etc.

It would be tiresome to detail the particulars of the good and bad contained in the multifarious assortment of international law that these Treaties present.

True, the Peace Treaty of 1815 established an era of pacification throughout Europe and America. Industrial enterprise and commercial rivalry were actively inaugurated, and, as usual under excitement of competition, every advantage for the securing of trade was studied, and hence the greatest commercial freedom and privileges in navigation were offered by our statesmen to foreign nations in the hope of outrivaling our rivals for the great trade in industry of our recent enemy in war.

Thus it was that within six months an agreement was negotiated with Great Britain, almost upon her own terms, in peace, after our victorious struggle in war, which permitted her to exclude us in trade from her colonies, and to gain an advantage over us in navigation, under a negotiation denominated the "Reciprocal Commercial Treaty of July 3, 1815."

This Treaty, extended in 1818 for ten years, was afterward renewed in 1827 for time and eternity (?), it seems, as we are still handicapped by its inequitable specifications and prejudicial advantages in favor of Great Britain—*mirabile dictu!*

That antiquated curiosity of American folly of 1815, our Treaty with Great Britain, faces our statesmen of to-day, as well as of the past, as an obstruction to equalization of commercial conditions, and particularly to the carrying trade between us and nations.

It needs no proof to assure us of this fact. That most profound statesman, Daniel Webster, spoke emphatically, and recorded his opinion thereof, and of our humiliation, in ridicule of the errors that make up our present condition.

Mr. Webster said in an address at Baltimore, 1840:

> "I do, gentlemen, entertain the strongest belief that the principle of reciprocity acted upon by the Government is wrong from the beginning, and injurious to the great interests of the country."

Mr. Webster was too diplomatic to express his candid judgment while arbitrating upon other conditions with Lord Ashburton; but let those who claim Daniel Webster as an advocate of "Treaties" review his emphatic words here:

> "By every Reciprocity Treaty we agree to give to every nation with which it is concluded a right to trade between us and other nations on the same terms as we trade ourselves—to give to the Hanse towns and the other States of the same class the right to fetch and *carry between us and all nations of the world on the same terms as we do, and practically they can do it much more profitably.*"

Here is the secret of England's success — she determined to wield a strong influence throughout the world by carrying the trade of every nation, and this was accomplished through subsidizing her largest steamship companies — which is still continued.

Mr. Webster further expounded the question thus:

> "We ought to give to every nation the right of bringing her cargo here in her ships if she gives the like privilege; but, by the Reciprocity Treaties, to give for the carrying of a nation like Bremen, which has but one

port, all the ports along a coast of 1,500 miles, with 17,000,000 of people, when she has scarcely 200,000 of her own, pray what sort of a Reciprocity is this? It is very much like the horse and the cock, who were walking together. *The cock thought to make a 'Reciprocal Treaty' with the horse —'I will not tread on you if you will not tread on me.'*"

A finer caricature of "Reciprocity Treaties" could not be more dryly or poignantly portrayed.

The great Webster was not alone in his contempt for such international law. The opinion of his successor as Secretary of State is here appropriate; that brilliant and faithful statesman, whose career was suddenly ended by accidental death, Hon. Abel P. Upshur, in his report Nov. 24, 1843, in presenting to President Tyler the condition of agreement creating the "Germanic Association or Customs Union," known as the "Zoll-Verein," referring to Mr. Webster's report of 1841 upon the same subject, and after pointing out the advantages contemplated thereby, and referring to instructions given to our Minister at Berlin, Mr. Wheaton, to establish a commercial arrangement between our country and the states of that Customs Union, viz.:

"To effect the long-cherished object of procuring the reduction of the present duty on our tobacco, secure the continued admission of our cotton free of all duties, and prevent the imposition of any higher duty on rice than that which is at present imposed."

Mr. Upshur points out the advantages offered by this Zoll-Verein and cites in contrast the exactions of England, France and Austria toward our trade relations and adds:

"There is reason to apprehend that if the best advised measures be not promptly taken American commerce will soon be engrossed by the ships and seamen of Europe."

Alas! how prophetic the warning; how true the prophecy to our present condition is the result of this so-called "Reciprocity Treaty of 1815!"

Mr. Upshur continues:

"*There can be no doubt that the cause of this great evil is to be found in the stipulations of our Treaties, which place the shipping of foreign countries on an equality with that of the United States in the indirect as well as the direct trade.*"

It seems difficult to find any defence or excuse for our impolitic provisions, and deplorable disadvantage in shipping conditions.

The Hon. Mr. Beck, of Kentucky, one of the ablest and most

earnest advocates of free trade, at a dinner in New York city last year, made the following remarkable admission of the disadvantage under which we labor in our commercial relations with foreign powers under our antiquated treaties.

> "I am, perhaps, unfortunate in lacking either veneration or respect for antiquated laws. I deny the right — yes, the power — of the Federal Government to make Treaties with foreign nations authorizing them to engage in our ocean-carrying trade upon precisely the same terms that our own citizens may."

This frank admission applies more particularly, necessarily, to the treaty of 1815 with Great Britain than to any other nation, and is a most forcible and patriotic reflection upon our international commercial relations, although the final expression detracts from the good point taken.

But this question is one of so much importance to-day that its discussion has been agitated recently and ably expounded by the Hon. Mr. Morrill, of Vermont, of the Senate, under the following resolution:

> "*Resolved*, That so-called reciprocity treaties, having no possible basis of reciprocity with nations of inferior population and wealth, involving the surrender of enormously unequal sums of revenue, involving the surrender of immensely larger volumes of home trade than are offered to us in return, and involving constitutional questions of the gravest character, are untimely, and should everywhere be regarded with disfavor."

That these two distinguished senators, of antipodal ideas, politic and economic, should at least agree in condemning the hypothetical benefits of our so-called Reciprocity Treaties, is certainly a suggestive thought.

HOME MARKETS.

The Hon. Leverett Saltonstall, of Massachusetts, the father of the United States tariff of 1842, in his able report of that year, epitomized free trade and reciprocal treaties. Mr. Saltonstall pleaded that—

> "A departure from the policy under which duties on imports have been so arranged as to encourage *domestic industry*, it is feared, would be most disastrous. Foreign nations would flood this country with their productions and destroy our manufactures by depriving them of the home market. The operation of it would be like that of our *reciprocal treaties, as they are called*, under which we have lost a great part of the carrying trade of our own produce."

This evil has so long been a subject of complaint that it has frequently been recommended that an "auction duty" would check the excessive shipment to our ports of refuse stock of foreign goods sold here at any price and proceeds remitted in specie to the great injury of our business community.

Mr. McLane, Secretary of the Treasury, sent a draught of a bill to the House for this purpose in 1832.

The economy of a home market to which Mr. Saltonstall refers has been discussed in the preceding letter of this series, and its connection with this letter in regular order is here emphasized; Mr. Saltonstall speaks forcibly, further, on page 20 of his same Report, as follows:

"Thus, it is that in sixteen countries of Europe, in which, if anything like reciprocity of terms were observed, over *four hundred thousand hogsheads of American tobacco*, worth, before shipment, about *thirty millions of dollars*, would probably be consumed, the enormous burdens imposed upon the article by the Governments of those countries limit the introduction of it to less than ninety thousand hogsheads; and upon the amount so introduced into their consumption, costing in the United States less than seven millions of dollars, a revenue is charged and exacted in Europe amounting annually to over thirty-five millions of dollars.

"*Without adverting to any other articles*, these instances have been deemed so striking as to call for some notice in our legislation, in the hope that foreign Governments may be thereby induced to reflect upon the propriety of some change in the policy which is so manifestly *destitute of reciprocity!*"

Why was Mr. Saltonstall compelled to make these reflections upon our reciprocity treaties, but because the free trade of commercial intercourse guaranteed was not equitable?

COASTWISE AND FOREIGN SHIPPING.

In coastwise and inland shipping the United States excels every nation of the world, because of the protectorate in wise navigation laws.

In foreign shipping the United States is the most humiliated in the world, because of our neglect to study scientifically the causes and results, *a priori* not *prima facie*, of this great economic.

Canada has shown far more scientific study, or certainly more practical application, than we have in this respect, and the best evidence is that she is making such rapid and sad havoc upon our transcontinental trade that it will not be long before the whole bulk

of foreign and even a great portion of our domestic freight and passenger traffic will be gobbled up to pass *via* the Canadian Pacific railroad and steamship line westward to Asia and eastward to Europe.

On both sides now, on the Atlantic and on the Pacific, we are flanked by heavily *subsidized* steamship companies; subsidized by the Canadian government to nearly the amount of a million dollars, as well as by millions of subsidy paid by England and more by other foreign nations.

This is denied by the agents of the British shipping interests, who are supported as residents in the United States to fascinate with soft sophistry our general public, *in an educative* way, to make our credulous believe the idea that the government of Great Britain can do our carrying trade cheaper for us and only pay for carrying the foreign mails.

This is deceptive and absolutely untrue, and will, doubtless, be exposed before the next Congress.

America consolidated by railroad continuation from Alaska to Magellan.

From Behring Strait to Magellan we can *prospectively* see a continued and direct railroad communication between the three Americas, although none of us present to-day may really recognize that concentration of economic and sociologic conditions in our day; but if the people of Canada and the several peoples of our sister republics of Spanish blood progress one-half in proportion to the United States we could see it in *ten* years.

Surely, if Canada can appropriate $215,000,000 for the Canadian Pacific Railroad, and go ahead with it as she has, it is by no means a chimerical project to contemplate a longitudinal railroad from the extreme north to the extreme south of our American continent.

But it is to the Canadian Pacific Railroad that I would call your attention.

This railroad, it is feared by many of our people, will rob the United States not only of her transcontinental trade, but also of our little ocean commerce that is left. So it will, if our statesmen lie supinely on their backs and see our commerce, our shipping and our railroad traffic taken from us without putting forth the same

scientific and economic effort in legislative skill and foresight to protect such interests.

But the Congress of the United States will act. It cannot do otherwise. There is the Canadian Pacific railroad cutting the state of Maine in half.

Already are Canadian railroads, as well as Canadian shipping, protected and encouraged, while our own interests are neglected. How long can this continue? The whole territory of America, north of the forty-fifth parallel of latitude would pass under the rule of the Dominion of Canada if the present aggressions upon us were to continue.

But we owe a duty to ourselves as well as faithful friendship to you, our neighbors.

The railroad condition of the world is as follows:

America	181,000 miles.
Europe	130,000 "
Asia	17,000 "
Australia, about	9,000 "
Africa	5,000 "

Thus it will be seen that America leads the world in railroad enterprise. Of this the United States has 150,000 miles; Canada, 12,000 miles. Here is a contrast in enterprise as in population.

There is so much in this, as especially in shipping conditions that require scientific study, that I greatly regret that in this address it is necessary to confine argument to but a brief review.

CONSULS AND DIPLOMATISTS.

"Commerce is king," wrote Carlyle; but he should have added, the Consul is premier in commerce. Mightier is he who makes the king than he who wears the crown.

The Consul has the power to guide trade and develop an immense economic work for his countrymen.

The Diplomatist has the greater influence in sociologic associations. He passes, as it is said, "the snuff-box with distinguished consideration," and manifests the ethics of intercourse, diplomatically, of course, between two peoples of antipodal tastes and habits, while the consul studies the means of aggrandizing all the commerce (or wealth) of the nation to which he is accredited in the most scientific manner possible.

In this science, as in foreign shipping protection, England has

outscienced all other scientists of the world, and the people of Canada have displayed similar talent.

This is another of the few superiorities that I am willing to yield in acknowledgment to our disadvantage; but it is one of the benefits that I trust we of the United States may be inspired to imitate by the approaching unification with the people once known as Canadians, as we were once known as Colonists.

The Consul is a power—where he is needed; but there exists at present a line of pickets along our dividing boundary called consuls doing a duty which is really the most preposterous farce that ever was known, except for *nominal* commercial relations and the fees of the post.

Who that has tried to study the commerce between the United States and Canada has not found that the trade passed secretly between the posts of custom-houses is as great as that passed legitimately? Lumber, clothing, animals, eggs, etc., are passed in and machines, implements, etc., are passed out *ad libitum* without duty or equitable exchange.

Of what value are the official statistics between our two governments under such circumstances?

OUR SOCIOLOGIC RELATIONS.

Social economy is a dependent condition—dependent upon the chance to regulate our national and personal welfare of the domestic family, to sustain existence, to accumulate comforts, and to hoard up all excess of income not needed for absolute immediate subsistence, that it may be reserved for contingent reverses or for indulgence of luxury.

In the economic phase of this subject, however, there must be a distinct line drawn between the expenses for necessaries and saving for luxury.

The man who, even by chance, inheritance, or hard industry, possesses wealth and trusts the loan of that wealth to his neighbors on faith without collateral security, hoping and expecting his prosperity to increase according to his happy ideas, would soon find himself the beggar of charity instead of the ruler of millions in personal wealth.

Take from social economy that reliance upon the security of collaterals and the healthy and sure regulation of justice through law prescribed and ordained by the science of political economy, and you rob the domestic circle of that incentive to industry and thrift

which is animated and guaranteed by the regulation of commerce, whether of small or great degree, under enactment of a politico-economic body of the people, and thereby also rob both rich and poor of prosperity and happiness.

In an interesting lecture before the Anthropological Society at the Columbian University, at Washington, some months since, Prof. Alfred Russel Wallace, of England, endeavored very seriously to teach us that all men could and should live as angels on trust, faith, hope and charity, and this beautiful theoretical creed is earnestly urged by many under the term of free trade. This would be revolution indeed.

Gladly might we accept such tenets as principles of political or social economy in temporal as well as in spiritual affairs were we assured that our neighbors would be as perfect angels as we could easily imagine ourselves to be.

But we are not. Neither man nor woman has yet arrived at that degree of perfection, even with all our progressiveness, in the United States, and certainly not in England, where free trade has been a national doctrine for forty years.

Professor Wallace was beautiful in his theoretical precepts and teachings, but we do not, unfortunately, partake of Divine nature or of those conditions of life essential to free trade relations and interchanges which are claimed peculiar to the isolated isles of Britain.

No wise financier would lend money even upon collateral if a lawsuit was anticipated to be necessary to recover his principal, but would he be willing to trust on faith?

What right in justice to his family? what sense of self-preservation and maintenance of honor would he maintain? how long before he would be ruined, were he to lend without security, or were our politico-economic laws compulsory to lend on faith, or, worse, to make a general division of the hard earnings of a lifetime?

It would be robbery to the poor man's thrift; it would be death to industry.

When the poor man can borrow from the rich without collateral, then that blessed theory of free trade will prevail—but not till then.

"Charity covereth a multitude of sins," but withal not the sin of debt!

Even Christianity is a failure in creating charity for the indebtedness of *one* dime.

A debt will be remembered by the creditor forever, though perhaps forgotten by the debtor.

This is not a national characteristic; it is an individuality, whether of Jew or Gentile. It was a very ungracious and incorrect reflection in Shakespeare to attempt to cast ignominy in this respect upon the Jewish people through the character of Shylock. The Hebrew people are as charitable as our own.

We must deal with ourselves as we are, not as what we should like to be.

As well might we guide our conditions by the delicate theory of Platonic love or govern ourselves according to the idealistic principles of Zenophon or Aristotle or Zeno, even more beautiful in principle, and as their philosophy teaches man to become, as to be governed to-day by the tenets of those later theorists, Adam Smith, Ricado, Say and Bastiat, who wrote of political and social economy according to the conditions in their age, but which were preëxistent to steam and mechanical development.

RACE AND RELIGION.

Nowhere in the world is a more conspicuous hatred manifested between factions of one people under one government on account of race and religion than is witnessed to-day in Canada. French, English, Irish, and purely Canadian races each retain and maintain their separate and distinctive identity.

Not even in Great Britain were the several races and religious divisions of England, Scotland and Ireland more antipodal in their tastes and habits or bitter in their hatreds in olden times than are the French and the British colonists—the Roman and the Anglican churches—of the Dominion to-day.

Mr. Beaugrand is as positive in his expressed written views of this fact as Premier Mercier is earnest in his eloquent avalanche of oratorical emphasis.

Can any nation prosper as a people under such prevailing feeling?

It is in fact an ill-assorted combination of two peoples under a cold autocratic government, without any softening provisions to ameliorate racial prejudices or animate religious ties.

Canada will disintegrate herself upon her racial and religious conditions, for we see in our neighboring friends at present the anomaly of a predominating race governed under an uncongenial authority.

In the United States this antipathy cannot exist, as our form of government destroys such feeling of rivalry, because the natural passions of jealousy, dislike, or ambition have nothing to feed upon.

In exemplification of this as a fact we see that many of these very two peoples have migrated into several of our States and are dwelling in peace and prosperity, and Mr. Beaugrand has very truly said that in annexation to the United States—

"The French Canadians have no fear that they would lose any of their present privileges by coming into the Union. 'Whether as a province of independent Canada or as a State of the American Union, we should retain our right to local self-government, and I do not know of any sensible man among our people who desires anything more than that."

Such is the beauty of our Government in contradistinction to that of a monarchial form.

No "orange" nor the "green," nor yellow nor the red, can interrupt our solid blue by racial or religious feuds, but the Stars and Stripes alone can rule as the banner of our republican identity and as the symbol of protection in the development of civilization and elevation of mankind.

IMMIGRATION AND TRANSFORMATION.

Who and what are we, and who are you? is an important reflection.

It would be ridiculous for the people of Canada or the people of the United States to be termed Puritans of England, or Anglo-Saxons, or Celts, or of the Latin race, nor have we an identity with the aborigines of this Continent.

We are Americans!

In this fourth century of America's discovery and name, it is an interesting as well as scientific study to ascertain our component parts and learn in what proportions we are, as a people, conspicuously developed.

When we compare the United States with Canada, in blessings that have accrued to us from wise foresight in provision, in the inception of our Government, "for the encouragement and protection of our industries," we should ponder upon the vast politico-economic advantages that have accrued to enrich our condition, extend and strengthen our influence, elevate our dignity, enlarge our liberality, and to command the respect of the world, and make our country the haven of refuge for industrious humanity.

The concentration of ingenious brain, the multiplication of thousands of dollars per immigrant in wealth of labor, the purest and richest virtues in industry and thrift have by immigration been blended into our conditions.

But in our "free land" and under "free institutions" does the immigrant expect to find our home doors open or unprotected, our offices and factories unrestricted from intrusion, or as "free" to the customer as to the owner?

The United States is the refuge for the honest prince of industry from every part of the world, and he emigrates thither to better his condition, to elevate his standing, and to give to this posterity the pride and birthright of manhood. He is re-created from the chrysalis of social nonentity into a development under protection in his new life of earnest striving and saving through industry. Subjugation by low wages and humiliation in dress and food, as was the case in his foreign home, would be to rob him of pride and ourselves of economic results.

The international representation and cosmopolitan character of our people through the influence of these wonderful features of political economy is seen by the following exhibits:

1. Of the sanguinary ties blending us together as a people; and

2. Of the economic power thereby contributed to our wealth annually.

The official figures of the last census gave as

The total number having	Irish fathers	4,529,523
" "	German fathers	4.883,842
" "	British fathers	2,039,808
" "	Scandinavian fathers	635,405
" "	British-American fathers	939,247
" "	fathers of other nationalities	1,321,485
" "	native fathers and foreign mothers	573,434
" "	*foreign* residents of both parents native	33,252
Total[1]		14.955,996

The total number having	Irish mothers	4,448,421
" "	German mothers	4,557,629
" "	British mothers	1,790,200
" "	Scandinavian mothers	631,309
" "	British-American mothers	931,408
" "	mothers of other nationalities	1,226,113

[1]It may be remembered that our present industrial strength is only 17,000,000, and at previous census only 12,000,000.

The total number having native mothers and foreign fathers	1,337,664
" " foreign residents of both parents native	33,252
Total[1]	14,955,996

Thus the largest foreign element intermingled with us is the German, the second is Irish; these constitute nearly 70 per cent of the whole.

The recent remarkable increase of emigration from Germany to this country has excited that great Political Economist, Chancellor Bismarck, and it is not surprising that he seeks to guard his country from the aggrandizement of American industries by an increased tariff upon American meats, by prohibition, and, worse than all, from depopulation and denationality through American absorption by interdiction to his people of migratory privileges.

The official report of a Consul in Germany says:

"This unprecedented exodus is engaging the serious attention of the German economists, and especially that of Imperial Chancellor Bismarck. The former have been calculating the working value of the average emigrant, and state that the services of every laboring man leaving the country may be valued at $1,000; there can be but little doubt that every emigrant is worth that yearly amount to the United States. Computing the wealth the United States acquire by the influx of population on this basis, and estimating the number of emigrants to the United States during the year 1881, as having reached 600,000, the country would have gained in that period $600,000,000."

This reported loss of wealth to Germany is so reliable that it appears the increase of our *industrial* wealth from immigration has been about $800,000,000 yearly, of recent years.

To estimate carefully as to the money actually brought into our country per immigrant, we must first take the average number of adults and find the amount of specie added by this yearly increase of population.

Another German Consul writes on this point, viz.:

"That the following are the figures given me by the police authorities of this port: adults, 9,223; children under twelve years, 2,208; infants under one year, 519; total, 11,960."

This is a just proportion; or take even less, say, 75 per cent only as adults, we have last year, adults . . . 590,000
at a minimum amount per capita of $100
adding to our country a specie value of . . $59,000,000

[1] It may be remembered that our present industrial strength is only 17,000,000, and at previous census only 12,000,000.

Calculating this immigration as a settled part of our people, at the usual average of five per family, and with the minimum family expenses per month $50, and $600 per year, we add at this rate to our wealth yearly by increased circulation of money, about $500,000,000.

The intrinsic motive power for this extraordinary emigration is found in the simple fact that there is an instinctive yearning in man to better his condition and raise his family to the highest degree of education and refinement, and the emigrant sees in the United States the fairest basis of labor and most equitable standard of Christian liberty and political economy.

Thus we see a most powerful influence and benefit to our industry, and a most important point in our political economy through immigration.

In transformation of people our extreme northern states, Maine, Vermont and New Hampshire, in the upper part thereof, there has been for the last ten years a great development, viz., the exodus westward of many citizens of those states and the migration of French Canadians to fill the void.

But this is Canadianizing New England, and, although it has long been in my mind, I prefer to quote from an able article of Mr. A. L. Bartlett, in the *Forum* of August, which covers the point completely:

"How rapidly the French Canadian element in New England, the great rival there of the Irish in numerical strength, and zealous fidelity to the Roman Catholic Church, has increased, is shown by a few statistics from the manufacturing cities. In the city of Lewiston, Me., the children of Canadian parentage almost equal those of American and of Irish parentage combined. In Manchester, N. H., out of a population of 40,000, 12,000 are of this nationality. In Nashua, out of a population of 17,500, 5,500 are of this nationality, a gain of fully one-half in five years. In Lowell, Mass., they constitute one-third of the population. In Holyoke the children of Canadian parentage are to those of American parentage as five to two. In Fall River, in 1859, there was one French Canadian family; in 1874 this class had increased to 6,000 souls; in the next decade that number was more than doubled; and to-day they number there full 20,000. In Woonsocket, R. I., they constitute two-fifths of the population.

In the public schools of Manchester, out of 3,670 pupils enrolled, 1,437 were the children of aliens—French, German, Swedish, English, Scotch, Nova Scotian, Italian, Norwegian, Danish, and Russian. In Lewiston, Me., out of 6,781 minors, only 1,859 were of American parentage, the nationalities of the others being as diverse as those mentioned above. In Holyoke, Mass., out of 6,297, only 843 were of American parentage. In

Woonsocket, R. I., less than half the children of school age, as given by the school census, are enrolled in the public schools, and the school report of 1888 says:

"The influx of French Canadians in every year is quite large, and it has become a serious question how they can best be assimilated. The education of the masses is with us a fundamental principle. . . . Schools are established, instruction provided that the children of all alike may become useful and patriotic citizens. But do we realize that there are hundreds of children going to school here whose instruction has no more to do toward making them good American citizens than does the instruction of Canadian children?"

It is our form of government which influences good citizenship, the incentive of pride to be elevated.

This is a matter of *as happy* satisfaction, as it is true, and proves the unifying power of our grand government. In connection herewith I especially point to comments upon education on another page.

UNIVERSAL LANGUAGE.

Speech is the most powerful agent in the world; the most assimilating element in life; the most comforting to all sensibility.

It is a happy solace to think of our grand Anglo-Catholic Creed "I believe in the Holy Communion of Saints;" but with the living there can be no communion of thought or mutual interest of purpose without the interchange of soul in one language.

"Two souls with but one single thought,
Two hearts that beat as one,"

can only be realized when the lips speak one tongue.

This is why we of the United States, although so cosmopolitan, are so assimilated and unified; because in every state one language is recognized in all educational and industrious pursuits.

The reason why Canadians are not unified in themselves is because of the want of this influence.

There is no greater mistake of the Roman Catholic branch of the church than the service in the Latin tongue. Were this error corrected the natural sympathy of that solemn form of worship would be far more impressive upon the mind of the listener and far more powerful in winning American converts to that faith.

Let us reflect that the English language is now general *in every part* of the globe. This cannot be said of any other language under the sun. Think of it!

In America, Europe, Asia, Africa, Australia and Oceanica the English language is heard extensively, if not by a vast majority.

The idea of Volapük becoming a *universal* language is absurd in the extreme.

A language cannot be issued by one man, it must grow naturally with generations.

Who could have made the English language, although the great Johnston, the reflective Webster, and the critical Worcester, and many others have from time to time improved it?

Look at a small table of figures to see at a glance the relative condition of the principal languages to-day:

English,	by about		150.000,000	tongues
German,	" "		70,000,000	"
French,	" "		50,000,000	"
Spanish,	" "		40,000,000	"
Russian,	" "	(purely)	32,000,000	"
Italian,	" "		30,000,000	"
Portuguese,	" "		8,000,000	"

The *London Times* recently very pertinently remarked:

"The commerce of the world cannot go on without English. Let the traveler stop where he chooses, he will find the Greek, the Jew, and the Scotchman carrying on business. They transact it, however, in English and through an English firm or an American one. Smaller branches of trade fall to the Frenchman, the German, and the Italian—the Portuguese, as a rule, occupies himself with the leavings of the rest—but each and all have acquired for practical mercantile reasons a sufficiency of English to make himself understood."

To England unquestionably belongs the credit of being the great disseminator of the English language by the control of the greater part of the world's shipping, and it is to be hoped that we Americans will imitate and help her in this great work.

GENERATION AND POPULATION OF THE CONTINENT.

We have looked into the natural condition of our two countries. We must follow the growth of each to know what is likely to develop still further.

It is easy to see our *preponderosity* in population, but which of us has the smartest brain remains to be seen.

The greater generally absorbs the less, but there can be no unification by force or numbers or power.

England's experience with poor old Ireland shows clearly to the

world that although there may be a coerced *union* there is not unification.

But look at the official figures which show the proportions of both country and people by the following tabulation:

Let us take the figures *in round numbers* of conditions just here.

	Area.	Population.	Density.
The United States[1] . . .	3,600.000 sq. miles	65,000,000	18.
The Canadian States . . .	3,500,000 " "	5,000,000	1.42

And also let us estimate ourselves with Great Britain thrown in with Canada.

	Area.	Population.
The Canadian States, ...	3,500,000 sq. miles	5,000,000
Great Britain, ...	121,000 " "	36,000,000
Canada and Great Britain, ...	3,621,000 sq. miles	41,000,000
The United States, ...	3,600,000 " "	65,000,000

And what are we coming to? Can Canada vie with us in advancement? Certainly not without us, for see the proportionate growth of the two peoples in the past. And what will it be in the future? It is estimated that the rates of increase of population by births over deaths is at present two per cent. Taking into calculation our yearly increase of population from immigration and our past decadal census, we find it to be but a reasonable estimate to predict for the United States — without Canada — in the year—

1900 a population of 85,000,000,

2000 a population (at least) 500,000,000.

This is not speculative, but as likely as it is that the world will continue "to bring forth its fruit," and that mankind continues to produce issue.

What our moral conditions will be depends upon our continued development of good sense and refinement.

Where shall we put this overflowing population except to spread them over the vast and vacant fields of Canada.

EDUCATION.

The chief bulwark of industry, identity and mutual interest in the United States is our public (free) school system; but there is much improvement yet to be made. Political economy and social science should be more generally taught for the higher elevation of

[1] Including Alaska, which has proved to possess great wealth.

national and local administration and for the better amelioration of domesticity among our people.

Not only is the education of the masses an essential element to the prosperity of a people, but that education must be in our own country.

There is nothing more conducive to unfit the youth for nearly all the paths of American industry than a cultivation of foreign taste and notions in children than a foreign education. Upon this important point I wish to cite the opinion of General Washington, who wrote:

"It has always been a source of serious regret with me to see the youth of these United States sent to foreign countries for the purpose of education, often before their minds were formed or they had imbibed any adequate ideas of the happiness of their own, contracting too frequently not only habits of dissipation and *extravagance*, but principles unfriendly to republican *government*."

The standard of education in the United States to-day is the best and highest in the world.

U. S. Consul Potter, at Crefield, writes to the Department of State, in regard to the unhappy influences upon the American youth studying abroad, especially in Germany, that—

"to such influences none are more sensitive than the nervously organized young American,"

who is sowing seeds for the future — either for usefulness or extravagance.

Consul Potter very truthfully and forcibly adds that "a cultured American who has mastered any single subject of study in America would not (at this date) find much in the same line of study to learn in Europe."

CONSANGUINITY AND MARRIAGE.

There is an influence developing more steadily and progressively which will inevitably prove a much stronger British investment in the United States than any syndicate of the many being formed.

These numerous matrimonial syndicates are investments, however, that will eventually undermine the British government and make Canada and the United States one at heart, one in family and one in home.

It strikes me that these are the wisest investments made by our English cousins; for, though it seems so far to be the case that

Englishmen get the money and our American girls only get the imaginary crowns or titles, the Englishmen, notwithstanding, obtain most irrepressible rulers, who will wield so developing an influence over them, though they never wore a crown or title before, but who are so thoroughly indoctrinated with Republican principles and associations that it must surely be ingrafted in their posterity—their children and children's children must inherit the spirit of a mother.

POLICY OF ECONOMY THAT CREATES MONOPOLY.

Monopoly is a word of such general meaning, and applied as a term, of such antipodal significance, that when used to indicate economic conditions its sense may or may not be complimentary. If monopoly is used to indicate advantages or preferences in economic legislation, and if such legislation favors one branch of industry or class of people to the injury of the other, that monopoly should be wiped out immediately and entirely; and if such were applicable to protective tariff enactments we should and would abhor and denounce the injustice with earnestness. But wherein is an industrial protective policy a monopoly — when the farmer gets protection on the value of his farm, his horse, or his product?

Then it took a large quantity of his product to buy an English carriage, a clock, or even a plow; it took the value of his horse to buy any small article of machinery, and especially if it was of foreign manufacture.

Now he pays only from five to ten dollars for a plow, and yet his horse has about the same steady value. Now, one-fourth of that part of the produce he paid for any implement then will be ample in value of exchange. Such results may be called monopoly of protection, but such monopoly has not hurt the farmer, the merchant, nor the country.

How purely selfish it is, then, in the Cobden Club writers, and how inconsistent in American statesmen, to appeal to American farmers — as their friends — to believe the doctrines adverse to the farmers' interest!

There is not a branch of industry, mental or physical, that has not been simplified, improved and cheapened; there is not an article of home or foreign manufacture (of iron or any other material), of mechanism or ingenuities, essential to labor and to our wants in trade or household comforts, that have not been made

cheaper in price; and where is the man who desires to give up the advancement, the independence, the refinement, the education, the thrift and all the blessings brought about by this so-called monopoly.

That monopoly can only exist under *free* trade, and that *free* trade can only exist under the protection of monopoly is unquestionably clear, in the fact that it was only the monopoly of iron that developed British manufacture, the monopoly (throughout the world) of her many and developed manufactures that induced and enabled her statesmen to open British ports as the *sans-souci* marts of inequitable trade.

If industries or trade require protection, it is against that monopoly; hence, the absurdity of the weaker condition monopolizing the greater. It is to destroy monopoly that protection is necessary; it is as necessary to discriminate in the policy of protection as it is discreet to protect only where necessary.

Protection is not for the benefit of monopolists at home; it is to defend us from monopoly from abroad — from foreign monopolists of capital and of pauper labor, from the monopoly of the world's foreign carrying trade, from monopoly of foreign banking exchange and from a foreign controlling influence over our commerce through commercial letters of credit from the monopolizing conditions of the Lloyds Insurance, which alone is a triumvirate of insurance, shipping and official protection thereto through the British consular service.

Monopoly is only powerful where conditions are left *unregulated*, where the greater absorb the lesser, and where the poor are most subject to the rich and influential.

But as a feature of political economy in import duty of our country the truth is recorded in the pages of official history of our country's past.

The power of the *foreign* "Importer's Monopoly" is exhibited in the investigation of the working of the boasted tariff of 1846. The importer of the United States is peculiarly of a duplicate character in his relation to the politico-economic conditions of our country.

It may not be generally known, but of this class of our community seventy-five per cent are foreign, representing foreign capital and foreign industry; twenty-five per cent, only, being the ratio of Americans possessed of home capital, of home ties and

home interests, nationally or individually, in the importing trade of our country.

It is the former who control a monopoly of our foreign trade, and who with watchful eye antagonize every clause in legislative acts that tend to interrupt that status that they have steadily developed, and the spirit of monopoly evinced since the colonial taxations for foreign staples that drove our fathers to independence in person and protection in industry.

It is not from the latter class of importers that the cry comes for free trade as an economic principle, but their cry is, to be saved from the "undervaluations," the "impure grades," and the "tricks of the trade" that have been made, and will always be made, under an approach to free conditions or deceptive ad valorem rates of custom duties. So ruinous a result from such a system can only be understood from the evidence of those who have suffered, but the importance thereof justifies the citation in corroboration of fact in contradistinction from fallacy or theory.

So far from the industry of manufacture being a monopoly under an economic policy of impost duty, it is conspicuously incorrect to every clear and impartial mind, after careful study of the causes and results in our condition.

On the contrary, the great number and variety of classes who are benefited by such protective system are as fourteen is to four; proportionate to the census return of those who in their industrial occupations have the great benefits of such economic safeguard without the fear of financial risk or apprehension.

A home demand, from a large and steadily increasing custom at our own doors, is far more secure than the patronage of rival foreign nations, whose purchases from us depend upon the contingencies of the production or scarcity of other parts of the world and the prevailing relations of peace or warfare between nations.

There are many causes influencing a monopoly and depression of commercial patronage from foreign nations that are necessarily prejudicial in trade and conducive to a sudden excess in demand and shortness in supply, and also to as sudden a reverse.

Monopoly, then, lies in foreign banking exchange, in foreign insurance, and in foreign shipping, which secures to foreign imports an undermining influence upon our home industry that tends to consume our strength in commercial relations, notwithstanding our resources and home enterprise. Such monopoly, if allowed to de-

velop, and surely if advanced by abolition of our protecting tariff, will result as injudiciously and ruinously to our people as such causes and conditions have ruined other nations in the past.

CONCLUSION.

An argument is too apt to present individual ideas or preferences; too liable to be based upon hypotheses or sophisms; too probable to be drawn in conclusion omitting some premise of reason or condition, a realism not sophism, that might materially alter the deduction made.

It is easy to accept an argument provided the sentiments expressed meet the sympathy of the listener or reader, but it is hard to make men agree whose immediate interests do not appear to them sufficient to give reflection to questions considered or whose ideas are of a diametrical tendency, although we all know many instances where parties have, after careful study or from some experience felt, learned the mistake they had made in judgment by finding conditions existing that had not before been apparent to them, because either they had been blinded by prejudice or thoughtless of the subject.

This is true even among students of economic science and statisticians in their deductions from official data, and the greatest care and frankness should be cultivated in verification of all those data and of historic records to guard against error and to perfect a scientific research for a conclusion.

An illustration of disagreement to be regretted, especially among economists, as, for instance, Condillac absurdly claimed as a principle of economy that there was an increase of value in the exchange of commodities, because, as he wrote —

> "If men always exchanged equal value for equal value there would be no profit to be made by traders."

This is a sophism, and exposed clearly by Jean Baptiste Say, who answers —

> "Since a sale is nothing but an act of barter, wherein one kind of goods, silver, for example, is received in lieu of another kind of goods, the loss which either of the parties dealing should sustain on one article would be equivalent to the profit he would make on the other, and there would be to the community no production whatever."

And plainly explodes such fallacy when he says:

"*The seller does not play the rogue nor the buyer the fool, and Condillac had no ground for his position.*"

Sismondi answers the sophism forcibly, as follows:

"*The trader places himself between the producer and the consumer to benefit them both at once, making his charge for that benefit upon both.*"

Thus we see that sometimes "even doctors disagree!"

It is far from my wish or thought that this brief analysis of the existing conditions and probable eventualities of our two peoples be taken in an autocratic spirit.

Not as Monarchists but as Republicans, and with the progressiveness naturally peculiar, and judging of the future by the past, with careful study and consideration, it seems to us that there is no future for Canada but in union with the United States, which is to-day *first in industry*, *first in educational system, and first in wealth* among the nations of the world.

We cannot go to you, but invite you — when you feel that you cannot help it—to come to us; and it seems beyond theory and more than a "glittering generality" to expect it soon for

"No pent-up Utica contracts our powers, but the whole boundless Continent is (or will eventually be) ours."

APPENDIX.

The following interesting and important comparison of the world's gold and silver product from the "Washington Press" of Aug. 27, was presented in the address.

GOLD AND SILVER VALUES.—AMERICA COMPARED WITH THE WORLD.

	GOLD.	SILVER.	GOLD & SILVER.
Germany,	$11,000,000	$283,000,000	$294,000,000
Austro-Hungary,	242,000,000	293,000,000	535,000,000
Europe,	2,000,000	330,000,000	332,000,000
Russia,	793,000,000	90,000,000	883,000,000
Africa,	376,000,000	1,000,000	337,000,000
Australia,	1,246,000,000	8,000,000	1,254,000,000
Other countries,	126,000,000	81,000,000	207,000,000
Total,	$2,796,000,000	$1,086,000,000	$3,882,000,000

SOUTH AMERICA.

	GOLD.	SILVER.	GOLD & SILVER.
Granada,	$623,000,000	$——,000,000	$623,000,000
Peru,	82,000,000	1,091,000,000	1,173,000,000
Bolivia,	145,000,000	1,517,000,000	1,662,000,000
Chili,	134,000,000	186,000,000	523,000,000
Brazil,	522,000,000		
All other So. Amer. countries,	40,000,000	12,000,000	52,000,000
Total,	$1,546,000,000	$2,806,000,000	$4,352,000,000

NORTH AMERICA.

	GOLD.	SILVER.	GOLD & SILVER.
United States,	$1,806,000,000	$863,000,000	$2,669,000,000
Mexico,	143,000,000	2,995,000,000	3,138,000,000
Central America,	13,000,000	2,000,000	15,000,000
Total North Americas,	$1,962,000,000	$3,860,000,000	$5,822,000,000
Other Americas,	1,546,000,000	2,806,000,000	4,352,000,000
Total America,	$3,508,000,000	$6,666,000,000	$10,174,000,000
Total Europe, Asia and Africa,	2,796,000,000	1,086,000,000	3,882,000,000
Total World,	$6,304,000,000	$7,752,000,000	$14,056,000,000

Percentage of Gold, 86 in favor of America.
" " Silver, 56 " " " "
" " Gold and Silver, 72 " " " "

PAPERS READ.

THE ECONOMIC CONDITIONS OF LONG-SPAN BRIDGES WITH SPECIAL REFERENCE TO THE PROPOSED NORTH RIVER BRIDGE AT NEW YORK CITY. By GUSTAV LINDENTHAL, C.E., Pittsburgh, Pa.

[ABSTRACT.]

THAT facility and rapidity of communication are a primary cause of civilization is recognized as an axiomatic truth. It is a popular phrase that the civilization of a country or nation may be judged from the number and condition of its roads.

The modern development of any country takes first the form of steamer lines, railroads and telegraphs,— all for rapid communication. It includes the greatest economic problems for human energy and endeavor: the economy of matter, power, time and space. As a special application we all recognize the great convenience and economics of unbroken and rapid communication over wide and deep rivers and estuaries, irrespective of wind and ice, by means of long bridges, and, where necessary, by means of long-span bridges.

The art of bridge-building is ancient; the science of bridge-building is modern.

The bridges of only a hundred years ago do not present any greater merits, if so great, as the bridges built one or two thousand years ago.

The bridge over the Euphrates at Babylon, built in the reign of Semiramis (about 835 B. C.)[1] and described by Herodotus, was as great an undertaking as any that we have records of to most recent times.

The diversion of a deep, navigable stream, 2,000 feet wide, for the purpose of building the pier foundations of that bridge, would also for our time be called a great work, were it necessary to undertake it.

China has stone and suspension bridges many hundred years old, of unexampled magnitude in any other country at much later times.

The limit in bridge construction, which human energy and enterprise could achieve on a merely empirical basis, had been reached long ago. The longest span of a scientifically proportioned stone arch bridge, "the Cabin John Valley Aqueduct Bridge" (220 feet span, built in 1870 by General Meigs, U. S. Army), had been anticipated nearly 500 years before by a stone arch bridge of 251 feet span over the Adda at Trezzo (built in 1380 and destroyed in 1430 by the Venetians). The latter had been built on empirical principles only; at that time the science of mathematical mechanics had not even yet begun.

[1] Other accounts ascribe the building of this bridge to the reign of Queen Nitocries, said to have reigned about one hundred years later.

The greatest and best of wooden bridges, to fifty years ago, were no greater achievements than was the often described great wooden arch bridge over the Danube below the rapids of the "Iron Gate," built in the reign of the Roman Emperor Trajan, 104 A. D. It was over 4,000 feet long and had 170 feet spans. Remains of the piers, founded in water eighteen feet deep, can yet be seen.

In military bridges, where fertility of resource and determination in the face of great danger are as important as constructive skill, the ancients and the mediævals have not been surpassed. The pontoon bridge over the Hellespont for the army of Xerxes; the pile bridge of Cæsar, built in ten days over the turbulent Rhine and in the face of the enemy; the pile and flat boat bridge, built by the Duke of Parma (in 1584 over the tidal river Schelde, 2,600 feet wide and 60 to 80 feet deep) during the siege of Antwerp — each of these achievements has not been excelled in modern history, considering the resources of the respective times. Human energy, enterprise and intelligence have, it seems, been the same, as far as history can inform us, of the great and powerful nations that have lived and gone; but human knowledge has increased and with it the field of its application.

Stone and wood have been superseded by iron and steel as material for the superstructure of bridges. With the development of the metallurgical arts, with the cheapening of the once costly metals, came their use for bridges in a manner and in a magnitude that would have been considered fabulous two generations ago.

The art of iron bridge-building is less than one hundred years old; the science of bridge construction is less than forty years old — very small periods, indeed, as compared with what it will be in the future. And what has been achieved? While a compendium of bridges ten years ago would hold within a slender volume an account of all the great structures of recent times, these have multiplied to an extent that would fill many such volumes now.

And the time of iron and steel bridge-building has only begun. Imagine what it will be when the second centennial of the inauguration of Washington as first president of the United States will be celebrated!

The North river at New York will be spanned by more than one bridge. The East river, bridged at present only by the magnificent suspension bridge at Brooklyn, will have as many great bridges over it as Chicago has now over its narrow river.

In anticipation of the first bridge intended to be built over the North river at New York, it will be interesting to consider the leading economical principles for long-span bridges in general.

1. SELECTION OF THE BRIDGE TYPE.

The science of bridge-building, having and progressing from a mathematical foundation, enables the engineer to work out results and to predict effects with increasing precision. We can closely calculate the stress in each member and proportion its strength for any condition of loads. We can tell in advance how much a bridge will deflect under certain loads,

or under temperature effects. We can determine its rigidity, even the extent of oscillation under defined speeds of railroad trains.

The principal types and combination of types, their merits and demerits, are now better understood,

Several kinds of trusses, which only a few years ago were frequently built as having special vague advantages, have become obsolete and have gone out of use. Experience, and a more rational and developed analysis of strains and of the dynamical effects, point to the gradual elimination of other types yet used for construction.

The first long-span bridges, by which may be understood bridges of steel and iron of about 400 feet or more in length, for railroad purposes, have been built in England. They were of the type called "tubular girders," of which the well known Britannia bridge (built 1850) in England, and later the Victoria bridge at Montreal, Canada, with shorter spans, are the most prominent examples. In their design, theory and empiricism were yet intermingled in determining their dimensions. Though very wasteful in the use of iron, in their conception and execution these bridges will always remain monuments of great engineering skill. They must be judged by the standard of their own time. The same bridges, built on modern designs and of greater strength, would require less than one-third of the metal and could be built in less than one-fourth the time for less than one-fourth the cost. Greater bridges are now built as an every-day occurrence. Their cost has been decreasing yearly, though it may not perhaps continue to decrease materially for some time to come.

For spans exceeding 500 feet in length, ordinary truss bridges lose their economical value, and other bridge systems offer greater advantages.

All single-span truss bridges, whatever their form, whether parallel chords or not, whether full or latticed web, or whether the open, large panel web of special American design, belong to the class of beams.

Like any ordinary wooden beam, if lengthened out to cover several spans as a whole or continuous beam (instead of being cut into several single beams, one for each span), iron trusses, when so made continuous over several spans, show increased rigidity and strength and economy of metal. The calculation is somewhat tedious, but this is a matter only for the engineer who builds them and no objection to their use, where reliable foundations can be obtained.

The next type or system, now largely used for long spans, is the so-called cantilever bridge. Like all others, it is very old and has been used in the remotest times, built of stone or wood. It simply consists of two brackets, corbels, or projecting beams, anchored fast at one end and reaching out beyond the supports till the opposite ends meet and are connected. Sometimes a beam is suspended between these ends or supported on them.

The modern novelty consists in the construction of this system in steel and iron. Its application on the largest scale is in the Forth bridge, now nearing completion in Scotland, where the two channels of an estuary, each 1,700 feet in width, have been bridged in this manner for a double track railroad. Numerous examples on a smaller scale exist and are con-

stantly added to in other parts of the world, particularly in East India and in North America.

The erect arch is, like the former types, also of ancient origin; though for the simple constructive needs of the oldest historical nations, it was not as frequently used as the beam and the corbel or cantilever. The Romans were the first to apply the arch principle to timber bridges, after having used it long before for stone arches. Cast iron was the next material used for arch bridges, the oldest of which was built only about one hundred and ten years ago, namely, the bridge over the Severn at Colebrookdale.

Since then arch bridges in cast iron, wrought iron and steel have been built in all parts of the world, some of them beautiful and very substantial structures, promising to last centuries. But so far no greater span than 540 feet (in the Garabit bridge in France) has been constructed. The arch type lends itself very well and economically to much longer spans than either the continuous girder or the cantilever system, provided the local conditions are favorable for the necessary substantial abutments against which the arches rest.

But the bridge type preëminently adapted for the very longest span attainable is that of the suspension bridge. It is as old as mankind itself and may be even older. Zoölogists tell us of the methods employed by apes in crossing streams. Failing to find a fallen tree to act as a beam or truss bridge, or failing to find meeting tree branches, forming a sort of cantilever bridge, apes, we are told, form a chain by hanging together hands and tails, and suspended thus over a stream from tree to tree, the rest of the tribe climb along this living bridge from shore to shore. The strength of the chain with its weakest link was, in this case, the weakest monkey, and there can be little doubt that occasional failures of such living bridges may have engrafted that bit of wisdom already on our anthropological ancestors. Modern bridge engineering, based on mathematical deductions, could not improve it. When Montgomery in his famous description of the Brooklyn suspension bridge, referred to its ethnical origin in the suspension bridge of the savage — the two stumps of trees as towers, the rope of twisted creepers, fastened at either shore to boulders as anchorages — he described a comparatively advanced stage of remote suspension bridge-building.

We have an account of a Chinese suspension bridge, equal in magnitude of span to Roebling's Niagara suspension bridge (800 feet). It was built of chains in the first century; remains of it still exist.

Since a suspension bridge requires, of all bridges, the least amount of metal, it is quite natural that the first metal bridges should be of the suspension type on the same economic grounds which, to this day, determine its choice. The facility with which they could be erected induced bridge builders to use them for longer and longer spans. The first longest-span bridges were of the suspension type: modern bridge engineering has not discovered a more economical type for the very longest spans. It is, however, a noteworthy fact that scientifically the suspension bridge systems were the slowest to develop correct theoretical application.

If we consider the economical values for long spans of the five principal bridge types, we find that they are not the same. Lowest in the scale are single-span trusses. They have been built so far to 540 feet spans, which will hardly be exceeded in the future, This is considered their economical limit, beyond which the following types give cheaper and better bridges.

The continuous girder is economical only for a succession of at least three spans, of which the end spans should be at least one-fifth shorter than the middle span. This latter may reach to 2,000 feet for a railroad bridge. Two thousand feet may be considered the economical limit also of the cantilever bridge system. The Forth bridge, now building, of 1,700 feet spans, will likely remain for a long time the longest cantilever bridge in the world.

Spans of 4,000 feet could be bridged, if necessary, with a steel arch bridge for railroad trains. The roadway need not necessarily be on top of the arch as in a stone bridge, but may be suspended from the arch, as in the Douro arch bridge in Portugal. Arch bridges can also be erected without false work, if necessary. Several of the most famous arch bridges of modern design have been so erected, among them the largest, namely, the St. Louis arch bridge, built by the late Captain Eads, and the Garabit viaduct, built by Gustave Eiffel. Both have over 500 feet spans.

But where the local conditions are favorable to a large arch bridge, and particularly to the erection without false works, the conditions will be found, as a rule, favorable to a suspension bridge, capable of the greatest economy of all known bridge types, and the one type capable of application to the longest possible spans. Single spans of over 6,000 feet could be bridged for railroad trains, if necessary, with cables of steel wire having a breaking strength of 170,000 pounds per square inch, which is the strength of wire in the Brooklyn suspension bridge. But steel wire suitable for bridge building can be obtained now having a breaking strength of 240,000 pounds per square inch, if price for the same were no objection.

The choice of the suspension type for the proposed railroad bridge over the North river at New York city is justified:

First. By the local conditions, which require a single span over the most valuable and increasingly crowded water highway in the United States. The unanimous popular and local sentiment is against any bridge which would require one or more piers between the shores. Just as the East river, between New York and Brooklyn, has not been allowed to be bridged, and will never be bridged otherwise than without piers in the river, so the North river, between New York and Jersey City, more important yet as a commercial highway, is not to be bridged except with a single span, or it may be tunnelled.

A river span of 2,850 feet will span the entire river, and the two shore spans will be 1,500 feet each. The bridge will reach over valuable property on either shore, which otherwise would be destroyed and become useless for business purposes. It will be 150 feet high above the water.

Second. The North river suspension bridge can be erected without false works from anchorage to anchorage, for a length of 6,000 feet. Naviga-

tion and traffic on the streets need not be interfered with during the building of the bridge.

The suspension type is the most economical for the locality. Single span trusses, continuous and cantilever trusses are out of the question for such a long single span, for the reasons given above.

An erect arch bridge is impracticable. The foundations for the abutments would have to be in very deep water. It would be impossible to build them so secure that the thrust of the arches would not cause a yielding of the masonry mass on the foundation. The weight of masonry under water is only about one-half of that out of the water, on account of displacement. The resisting mass would have to be enormously large. But in very deep water it could not be perfectly bonded to the foundation, because of the impossibility of reaching very great depths otherwise than with dredging tools. The pneumatic method of foundation is not applicable to greater depth than about 120 feet. Beyond that the mortality among the working men would increase to a criminal and murderous extent. Some engineers would not risk the pneumatic method beyond 100 feet in material such as the bottom of the North river consists of, namely, mud with sand, with boulders and sand pockets down to deep rock in uncertain quantities, a combination liable to sudden "blowouts."

Fourth. The towers of the suspension bridge, which alone require the deep foundations, have to resist vertical pressure only. The foundations are not exposed to any thrust or other lateral force, as in the case of an arch bridge. The pull from the large cables of the suspension bridge is resisted by the large anchorage masses placed 1,500 feet back of the towers, where the rock rises to the surface. The cables can there be rooted into the rock. No sliding or sheering can possibly take place with anchorage masonry, bonded into the solid rock.

2.—THE NATURE OF THE LOADS OR TRAFFIC OVER A BRIDGE.

The nature of the loads or traffic over a bridge was always held to have a decisive influence on the choice of the type for long-span bridges.

Thus for wagon and street traffic, suspension bridges were considered safe and proper, but when the problem arose of long spans for railroad traffic, the most eminent engineers at first disagreed widely in their judgment. Still it is a noteworthy fact that already in the earliest designs for railroad bridges the suspension type was thought of and seriously considered. Thus the first designs for the long-span bridge over the Menai straits were on the suspension principle, stiffened by plate girders. From tests with models it was then concluded that the chains could be dispensed with for the proposed 460 feet spans if the strength of the girders were increased, and out of the original suspension bridge was evolved the tubular bridge, built as a continuous beam of four spans.

Brunel's bridge over the Saltash, near Plymouth in England, is derived from a similar idea of chain stiffening, but in this case the tube was ingeniously placed above the chain as an arch, the thrust of which equals the pull of the chain, and the bracing placed between them furnishes the required stiffening.

Roebling's success with long-span bridges for wagon traffic encouraged him to propose the railroad bridge on the suspension principle over the Niagara river. He reasoned that as the jolting of heavy teams on the suspension bridges he had built before produced no noticeable deformation, and that the oscillations became less the longer the span, the smoothly rolling loads of railroad trains would still less affect them. That his conclusions were right can be witnessed daily on his railroad bridge below the Niagara Falls (built 1854). This, however, was not the only suspension bridge built for railroad traffic. There was a chain bridge for a double track railroad in Vienna, built a few years later, which did excellent service for fifteen years. The rigidity provided for it, however, had, as in most suspension bridges, not been sufficient, and although safe otherwise it was replaced a few years ago with a modern arch bridge.

Theoretically, a suspension bridge is nothing else than an inverted arch bridge. The chains or cables take the place of the compression members of the arch. It follows that if the chains or cables were stiffened in the same manner and of same strength against deformation as in an erect arch bridge, both systems should be equally stiff and rigid. As a matter of fact, the suspension bridge requires less stiffening, and with less stiffening is more rigid. Erect arches require lateral bracing to keep them in an upright position; without it they would fall of their own weight. Suspended arches require no such lateral bracing: they keep their form without it; they are in stable equilibrium as compared with erect arches, which are in unstable equilibrium. The weight of that lateral bracing in an erect arch is a large percentage (from ten to twenty-five per cent) of the total weight of metal, which is unnecessary and can be saved in suspended arches. This is an important economic feature in a long-span bridge.

A suspended bridge can be built of any degree of rigidity or without any. It will be safe in any case, though it may swing and oscillate.

For comfort and for fast speeds it is undesirable to have a swaying bridge. It requires stiffening. The different systems of stiffening are not alike in economical value or in merit.

The most frequent system is that of stiffening trusses. In very long spans and for railroad trains they require to be very substantial and become enormously heavy, though by no means as heavy as they would be in combination with an erect arch. They carry no part of the dead or live load; their own load must be carried by the cables. Their sole and only function is to preserve the form of the cables under passing loads. The heavier the cables, the smaller and less frequent is the maximum work of the stiffening trusses, whose weight, however, is not decreasing with the increasing length of span, but is increasing merely at a smaller ratio.

Split the cables and insert between them the web-bracing of the stiffening trusses and the weight of the heavy truss chords is saved. The cables themselves will now act as the chords. They will form a curved stiffening frame, or suspended stiffened arch ribs.

The economy of the system is apparent, and it may be said that it is the most economical for very long spans that can ever be proposed, provided

anchorages can be obtained without such great cost as to overbalance the economy in the suspended arches.

The suspended arch is no more subject to deformation from trains than the erect arch, as already remarked. But the knowledge that a suspension bridge is safe, whether stiffened or not, has caused many suspension bridges to be cheaply built with insufficient stiffening, and as a consequence the notion has become popular that a suspension bridge is not rigid enough for railroad trains. This is a mistake which modern bridge engineers will not make. Empiricism is at an end as far as the rigidity and strength of suspension bridges are concerned. A truss bridge of any description, a cantilever bridge, or an erect arch bridge, if so badly designed or insufficiently stiffened as most of the existing suspension bridges are, would not stand a single load, and most of them would fall of their own weight the moment they were released from the false work. But a suspension bridge cannot fall as long as the cables and fastenings hold. What lighter bridge for the same load can there be of any one other kind than the one of a single wire rope on which Blondin walked across the abyss of the Niagara river?

The North river bridge is designed on the principle just explained. The suspended arch ribs consist of steel wire cables with the bracing between them—the cables are fifty feet apart. These arch ribs are so designed that they will preserve their form without change noticeable to the eye, even in the case of six processions of locomotives advancing on it on all six tracks.

There are only two such arch ribs, though there are six tracks to be ultimately increased to ten tracks. The reason for this arrangement is as follows: in a single track bridge the two trusses supporting it are strained to their full capacity, more or less, from each train passing over it; in a double track bridge only when two trains meet, on a three track bridge with two trusses, only when three trains meet; and so on to a six track bridge, supported by two trusses or arch ribs, the maximum load occurs only when six trains happen to meet on it. The probability or frequency of trains meeting on the bridge is in a greatly decreasing ratio from a double track to a six and ten track bridge.

A long-span bridge can neither be so heavily nor so frequently loaded as one of short span. An ordinary street car, 16 feet long, has about 120 square feet on which at times eighty persons are squeezed together in a manner not possible on a street or on a bridge. Still the load will hardly exceed 100 pounds per square foot of street car. On a street bridge of 100 feet span, it is conceivable that a crowd of people may congregate which would exert perhaps a pressure of 70 pounds on the square foot average, though for the calculation a load of 100 pounds per square foot is usually assumed, as including the effect of impact, accumulation of snow and ice, etc. But on a span of 1,600 feet, such an average load per square foot from a crowd would be a physical impossibility under ordinary conditions. Thus, if the Brooklyn suspension bridge (having such a span of 1,600 feet) should be loaded at the same rate as assumed for a

100 feet span, it would take a mass of humanity of nearly 170,000 people crowded together and suspended on the structure between the anchorages. The bridge would not yet give away, but long before only one-fifth of this number could get on the bridge, locomotion would be out of the question, and deaths by crushing in the crowd would be almost unavoidable.

Great, dense crowds rarely cover large areas: they cannot with safety to themselves do so, and therefore smaller assumptions of loads are justifiable for long spans when they would not be for smaller spans.

What is true of a street bridge is in a measure true of a railroad bridge. The length of train and its load will depend on the grades up to the bridge. That load which the two heaviest engines can haul up the grades to the bridge will usually be the limit of live load for a long-span bridge, provided that the train's length is shorter than the span. It is not conceivable in ordinary practice that such trains would follow each other closely on all six tracks at the same time. But the strength of the North river bridge is to be such that ten double-headed freight trains, running on ten parallel tracks — five in, five out — all meeting on the middle span of 2,850 feet, could meet on it regularly without doing the bridge the least harm. It is easy to believe, however, that such a meeting may not occur once in a generation.

This great strength is obtained with comparatively less material than in shorter bridges. The live load forms only a fraction of the dead load. The difference in the strains of the loaded and unloaded structure becomes smaller. Experience and exhaustive tests furnish us with the knowledge that this difference of the minimum and maximum strains has a close relation to the durability of the structure, and that the durability increases as this difference decreases. In other words, the durability of long-span bridges is greater than that of smaller-span bridges, not only by reason of the greatly lessened frequency of the maximum loads, but also by reason of the more favorable relation of the strains from dead and live load.

Examples of this truth we find everywhere; to name only a few, there are the long-span suspension bridges at Wheeling and Cincinnati, with an ever increasing traffic; they are as good as ever. They show no signs of deterioration, while shorter-span bridges of greater rigidity in their immediate neighborhood, built after them, have had to be replaced — they were worn out and unsafe. There is no reason why the existing long-span bridges should not last many centuries if carefully maintained.

3. SUITABLE MATERIAL FOR LONG SPANS AND ITS ECONOMIC FORMS.

As already pointed out, steel and iron are the only materials practicable for the superstructure of long-span bridges. There is no probability of anything else being ever used in their place. Aluminium, which is so often mentioned by enthusiastic progressists as the coming structural matetial on account of its lightness, elasticity, strength and ductility, will never be used, even if it should cost no more pound for pound than steel. The mechanical value of the best aluminium bars is only equal to that of steel bars of thirty-nine tons tensile strength per square inch. That is, taking

a steel bar and an aluminium bar, about 23,000 feet long, each would just support its own weight suspended. Aluminium has only about one-third the strength and about one-third the weight of such steel. Aluminium wire shows no increase of strength, while, on the other hand, that same steel, drawn into wire of No. 7 Birmingham gauge, would have a strength of about eighty-two tons. But steel wire of 150 tons strength per square inch can be obtained. Steel and steel wire will forever remain the strongest known materials for constructive purposes. Steel wire is preëminently adapted for long-span bridges. Aluminium will have many uses, but for bridges will not be one of them.

The economical value of steel wire has been enhanced by a gradually cheapened cost and an improved quality. For the Brooklyn suspension bridge, twelve years ago, the proper quality of wire could be obtained only from crucible steel, the most costly of all. At this time, wire, more uniform and just as tough and strong, can be obtained from steel made by the open-hearth process, at less than half the cost. The extraordinary toughness of this material is proven by the test of bending cold to a loop round its own diameter.

In very long spans saving of dead weight is of the greatest importance. Steel wire admits of its being done in an unsurpassable degree.

For the above described system of suspended arch cables of steel wire, the length of span which could with safety be bridged grows to over a mile in length for supporting railroad trains. It is doubtful whether the necessity will ever arise for such a length of span.

The durability of steel wire is as great as that of other iron or steel members, and it is more durable than stone in our climate.

Thus, in Roebling's railroad suspension bridge over the Niagara river, the wooden stiffening trusses were replaced with others of steel ten years ago. The stone towers were replaced with steel towers three years ago, but the original cables still exist and require no replacing, though since the bridge has been built train loads and locomotives have increased 60 per cent in weight, and the frequency of trains has increased at least 300 per cent.

The iron wire cables of the old Smithfield street bridge in Pittsburgh, built by the late John A. Roebling in 1847 (and rebuilt by the author in 1882 with a steel truss bridge of larger spans), did not show the least sign of weakness after thirty-five years of very hard usage. The cables in this bridge were light — only four inches in diameter—and from the heavy traffic over it were strained almost every day to nearly half their ultimate strength. The No. 8 wire (Birmingham gauge) was tested when the bridge was torn down. It showed no diminution of strength. The tests showed from 95,000 to 100,000 pounds per square inch, in spite of the hard usage of the bridge. The cables had never stretched from their original camber. Almost every part of the bridge, from the foundations up, was worn out and decayed, except the wire cables. They were made of parallel wires and wrapped with a softer annealed wire in the same usual manner as all later wire cable bridges, including the largest, the Brooklyn suspension bridge.

In the North river bridge the cables will also consist of parallel wires, but instead of being wrapped with wire they will be enclosed in a water tight steel envelope one-eighth inch thick, which will be removable in sections for the inspection and painting of the wires.

Between the consolidated wire cables and that protecting shell an air space of about two inches will be left to prevent uneven heating of the wires by the sun. Experience and observation on existing suspension bridges show that the sun does heat the cable unevenly. Certain internal strains are necessarily the result. They are not dangerous and are fully covered by the usual margin of strength, but it is desirable to avoid them altogether, which will be done in the North river bridge.

The diameter of the finished cables will be four feet. There will be four such cables; each two, fifty feet apart vertically, will be braced together to form the rigid arch ribs above described.

The connection of these braces to the cables will differ from those in use in being much stronger and so arranged that the couplings cannot slide on the cables.

The towers will be of the open lattice construction, to present the smallest possible surface to the wind and also for economical reasons. Stone towers are more costly, particularly for great heights.

From the cable arches will be suspended the platform, built of steel and arranged for accommodating ten tracks in two stories, six below and four above. The suspended steel girders, forty feet high, will be auxiliary to the arch ribs in their stiffening effect. Of themselves, they would not be sufficient to preserve the form of the cables, if that function were assigned to them. They would have, as already remarked, to be exceedingly heavy and much higher and would greatly add to the cost of the bridge. A heavier suspended structure requires heavier towers. Their foundations would have to be enlarged and the anchorage masses would have to be increased. The weight of the cables obviously affects the whole structure and its economy. To reduce then the weight of the suspended structure, the suspenders from the cables to the platform will likewise be made of wire cables. They will be six inches in diameter and made of wrapped parallel wires. Their weight will be only one-third that of wrought iron suspenders of same strength.

Another reduction of weight is obtained by leaving off the usual heavy timber ties for supporting the rails. These will rest lengthwise on cushioned bearings directly in troughs of longitudinal steel box beams, so arranged that a train cannot possibly leave the track. A strong wire netting will take the place of solid flooring. It is much lighter, does not retain water or snow and opposes no surface to a wind striking the bridge either from below or above. It will, besides, be strong enough to hold up a wrecked train.

Large as the anchorage masses need to be, and as they appear, their cost is not correspondingly great. If the foundations were on ground which had to be artificially reinforced for resistance to pressure and sliding, the cost of the anchorage would indeed be formidable. But as already remarked, the resistance will come from the unyielding rock itself,

and the anchorage masses are merely needed to hold the anchors down in the rock by their weight. This weight need not be obtained by costly masonry throughout, but a large part of the anchorage mass will be stone ballast encased in masonry. Its form is constructively and architecturally correct. The anchorage portals will really be tunnels, 300 feet long, and partly open on top, forming a grand and fitting entrance to the colossal bridge.

The absence of a similar portal feature in the great Brooklyn suspension bridge is universally recognized, but may some day yet be supplied.

4. PROVISION FOR TEMPERATURE EFFECTS AND WIND PRESSURE.

Steel and iron expand and contract in our climate at the rate of about one-half inch per 100 feet from a middle temperature of 60° Fahrenheit, or one inch per 100 feet between the extremes of 150° Fahrenheit. This would amount to 28–30 inches in the 2,850 foot span, provided the span were independent of the shore spans, 1,500 feet long. But such is not the case. Here the length of the whole cable, from anchorage to anchorage, must be taken as changing its length and concentrating the effect in the middle span.

The cables rest on the towers in large saddle castings on steel balls, and can move. As a matter of fact, the cable bearings could with perfect safety be made rigid, because the steel towers need to bend only about eight inches either way from the middle temperature to accommodate the changes of length in the cables. The bending strains from this movement in the towers are comparatively very small. The cables of the end spans do not change their form from temperature effects; they are free from temperature strains. The effect is all in the middle span, with a result of a lowering of the structure at the middle of about four feet in summer from what it is in April or October, and a raising of four feet in the winter time, or eight feet between the extremes. The Brooklyn bridge rises and falls two and a half feet, or five feet in all. The change is so gradual that it has very little influence on the grades of the railroad tracks.

The changing curve of the arch causes strains which can be accurately calculated and provided for. For an arch rib with two parallel members, the bending strains are largest at the middle of the middle span, and decrease to zero at the towers. The tension in the cables from the loads upon it is smallest at the middle and largest near the towers. It varies about ten per cent.

The wire cables must, for practical reasons, be made of the same diameter throughout, proportioned for the largest tension near the towers. There would therefore be an excess of strength of ten per cent at the middle of the span. It so happens that the strains in the middle caused by temperature changes require a similar increase in the sectional area of the cable at the middle, so that the above mentioned excess will be convenient to meet it.

This is an important economic question, and is solved in the design without requiring any extra section or extra material in the cables for temperature strains. But there is another difficulty to be provided for; a ribbed

arch, namely, can act as assumed only if it is free to turn as on a hinge on the towers. Not only temperature effects, but also all train loads would otherwise cause an overstraining of the cables there. It would take the form of one cable exerting a greater pressure on the tower than the other, and carrying a much greater part of the imposed loads. To avoid that irregularity, provision is made on the towers for balancing platforms, which support respectively the lower and upper cable saddles. These platforms are so balanced against each other that the cables under any and all conditions of loading or of temperature changes exert equal pressures, or, in other words, their reactions are always equal. One cable cannot be made to carry more load than the other. They must each carry their equal share, and overstraining of the wires is out of the question. This novel device, simple as it is, requires ingenious arrangements for its perfect working; during erection the cable saddles must be perfectly free to turn when the cables are swung from a vertical to their final inclined position.

WIND PRESSURE.

So far we have considered only the effects of vertical forces or loads upon the bridge; but it must be made secure also against lateral forces, of which wind pressure is the greatest. Indeed it would be very bad engineering which would not take into account the tremendous effects of gales on such a large and exposed structure. We have records of wind pressure lifting a heavy locomotive off the track and carrying it about fifty feet; of a 250 foot span double-track bridge having been torn from its anchors on iron piers and lifted and thrown into the river; of the large 1,100 feet suspended span at Wheeling (before it was as securely anchored to the shores below as it is now) being turned upside down and the cables twisted by a puff of wind hardly noticed in the city itself. Lately the suspension wagon bridge 1,000 feet span, below Niagara Falls, was nearly blown down, because one of the wind guys had become worn and broke at the fastenings.

These occurrences prove that the most unequivocal provision must be made against wind force in a suspension bridge.

While very great wind pressures exert their full force usually only over a narrow path, it is safest to proportion the structure on the assumption of a hurricane blowing squarely across it for the full length. The weight of the structure itself is an important factor for its safety in a gale of wind. Theoretically, a heavy and a light bridge having the same surface exposed to the wind would require the same amount of lateral strength to resist wind. But such is not always the case practically, and theory can be corrected thereby.

It has already been mentioned that a suspension bridge is in stable equilibrium as compared with the unstable equilibrium of an erect arch. This distinction has an important bearing on the sensitiveness of the structure against lateral forces against lateral rigidity.

The weight of an erect arch in a vertical plane has no significance and no influence against wind pressure. Whether it were of wood or iron, it would topple over in either case with the same ease if not specially braced.

It is different with a suspended structure. The wind pressure, trying to displace it, is resisted by its own mass and weight, and the moment the lateral forces cease it will return of its own accord to its position of equilibrium. The wind pressure, if not counteracted otherwise, could push the suspended structure only a certain small distance out of the vertical, and there it would stop. The greatest danger is with the wind striking the bridge from below and lifting it. This danger will not exist in the North river bridge because of its great weight, of the rigidity of the structure otherwise, and because of the open floor of wire netting which will let the wind blow through.

The stable equilibrium of the bridge will be enhanced in the same manner but in greater degree as in the Brooklyn bridge, namely, by inclining the cables toward each other, or by "cradling." While in this bridge the cables are cradled about five per cent, in the North river bridge it will be ten per cent, or twice as much.

Calculation shows that if a wind pressure of fifty pounds per square foot was exerted against the entire length of middle span it would have the effect of displacing the windward cable, with the structure suspended from it, ten per cent. from the perpendicular, so that the windward cable would then be in equilibrium without the opposing pull of the leeward cable. The wind bracing to be provided for is, then, merely that required to prevent the leeward cable from assuming the perpendicular. This reduces the wind bracing to a minimum. It is in the form of horizontal wind cables, two below and two above the platform. They will be very large—nearly twelve inches diameter—and composed of a number of bundled steel wire ropes.

There is a further arrangement by which these wind cables are always kept taut, independent of temperature changes, which otherwise would cause them to be much slacker in summer than in winter time. At no time will the structure be unprepared to resist a hurricane. It may be so great as to prevent the trains from running over the bridge, but will no more endanger the structure than solid ground.

The towers of steel, nearly 500 feet high, will be so wide at the base and of such rigidity that the greatest wind force will produce no oscillation.

5.—ERECTION OF LONG-SPAN BRIDGES AND ECONOMIC MAINTENANCE.

In the nature of things, very long spans will be only over deep, navigable channels, or over other places making a support for erection from below impracticable. They should therefore be erected without false works. Such is indeed the case with all the systems economically suitable for very long spans.

The continuous girder, the cantilever girder, the erect arch bridge, can all, as already mentioned, be erected without false works if necessary. But in none of them is the erection so convenient and economical as in the suspension bridge. It is here merely the question of erecting the first wire or wire rope over the towers.

In Roebling's Niagara railroad bridge, a small balloon took over the first wire. In the Brooklyn bridge it was a wire rope, which, at the signal of

a cannon, was hoisted clear from the bottom of the East river high above the mast heads and formed the first connection over the towers.

The cable of parallel wires is then usually built in place, strand for strand, in such exact manner that when finally all the wires are completed into one solid cable, the difference in their straining is no more, if so much, as if the cables were composed of bars solidly and carefully fitted and riveted together.

The method heretofore used for making cables in place is somewhat slow and tedious; improvements and preparations on a larger scale will be justified for the larger cables of the North river bridge, which will hasten their completion at least twice as fast. Special machinery and accessibility to every part of the strands will make it possible to carry on their construction and adjustment by means of electrical contact and signal apparatus irrespective of the weather, summer or winter. The degree of accuracy obtainable in that way would not be surpassed if, instead of the cable, there would be a solidly forged steel shaft throughout, if such were indeed possible. And assumed that a shaft of such size, with a strength of 170,000 pounds per square inch could be made, it would lack the pliability and elasticity of the wire cable, a most valuable quality for the durability and strength of the structure.

How long will such a bridge last? It is an unanswerable question in the present state of our science. If well maintained under the most competent engineering superintendence, there is no reason why it should not last as long as the Egyptian pyramids. They were built of more perishable material than steel and iron are, provided iron and steel are kept well painted and free from rust. Rust and man are indeed the only destructive agencies for such a structure. No tornado could blow the structure over. No earthquake could shake it down, unless it were so great that the rock would cave and split and swallow up the North river. The structure cannot be worn out by traffic, no matter how heavy locomotives and cars may yet be used. The heaviest cannon that could be transported over ground could be transported over the bridge. But let the structure be neglected; let it be assumed that this race and this nation die out and this country be again inhabited by savages, and the bridge would decay together with the civilization that produced and maintained it.

It is not likely that war between civilized nations would sanction the destruction of such a structure by bombardment. It would be needless, since the river itself could not, at the same time, be destroyed for communication from shore to shore. Civilized warfare protected the cathedral of Strasburg during the siege of that city; it protected the beautiful and monumental public buildings of Paris. (Their subsequent wanton destruction during the reign of the Commune was not by the enemy of the nation, but by the enemy of civilization.)

Man is more destructive to structures than decay and rust. The necessities of war may bring about the destruction of large bridges in the future as has happened in the past. This may not always be an unmixed evil, if inferior structures are destroyed and rebuilt by grander ones. The

taste and desire for architectural harmony are growing, though as yet the standpoint of utility, without regard to appearance, is too prominent in most of our bridge structures.

The majestic grandeur and beautiful outlines of a large suspension bridge must be seen to be appreciated. Whether it be the serene and simple architecture of the Brooklyn bridge or the ornamented Buda-Pesth suspension bridge with its link cables and with its exquisitely proportioned stone towers and anchorages, or one of the less noted suspension bridges, no other bridge architecture is more pleasing to the eye and the desire for their preservation is instinctive in civilized man.

There is no cause so insidious and so sure as rust. The alleged gradual crystallization of iron and steel under strain, which was once assumed as a cause for their wearing out, is a fable unworthy of scientific recognition. There are deteriorating causes at work to weaken the cohesion of these metals when abused and overburdened with work by unscientific design; but a modern steel and iron bridge is not a structure of that kind.

Keep out the rust, and in thousands of years the structure will yet stand. And if rust, or other causes, should endanger it, there will be engineers to replace the structure piecemeal without stoppage of traffic. It has been done already on a smaller scale with the Niagara suspension bridge and with others. Besides, it will not be then the first and only bridge over the North river. Others, and may be larger ones, will span the river and connect the shores in the then greatest city, not only of this continent, but of the world, past and present.

Eighty years ago there was on exhibition in the city of New York a model of a proposed wooden bridge, partly cantilever, partly arch, over the East river, of 1,800 feet span. Thomas Pope, an ingenious and ambitious shipwright, was the designer and originator of the project. He was also the projector of a single-span bridge over the North river, which he describes in quaint verse and from which we quote:

"Like half a rainbow rising on yon shore,
While the twin partner spans the semi o'er,
And makes a perfect whole that need not part,
Till time has furnished us a nobler art."

Since his time this "nobler art" has become a fact and an exact science, enabling us to carry out in steel and iron what he proposed of wood, with absolute certainty of result and of a magnitude that even he, Thomas Pope, a man far in advance of his own time, never dreamed of.

ADDENDUM.

The North river bridge referred to in the foregoing paper, is intended to be built from Hoboken across the river to some convenient point near Fourteenth street, in New York City. A glance at the map will show that this is the narrowest part of the North river in a length of over fifty miles, from Peekskill on the Hudson to the mouth of the river at the Battery in New York City. The river can be bridged here in one single span

cheaper than it could be done with a pier in the river, because it is here over 200 feet deep to the rock foundation.

A single-span bridge 2,850 feet wide and 150 feet above the water will not interfere with navigation.

The physical obstacles to the construction of such a long-span bridge seemed insurmountable. But there exists now no doubt whatsoever as to the feasibility of such a structure.

The North river bridge is very pressingly needed for the accommodation of the travelling public, arriving or departing on the railroads now terminating in Jersey City, opposite New York.

Every one knows that the present manner of landing the passengers in New York is antiquated and dangerous.

The two tunnels building at present will prove to be a great benefit to local travel, but cannot be expected to solve the problem of railroad crossing. A railroad bridge for ten tracks and with a footwalk promenade will meet the necessities of perhaps only the next thirty years, when another bridge may be needed.

Mere figures would not give an adequate impression of the gigantic work, but some idea can be obtained from a comparison with the great East river bridge, as will be seen from the following data:

	BROOKLYN BRIDGE.	NORTH RIVER BRIDGE.
Length including anchorages	3,700 feet.	6.500 feet.
Height of anchorages	85 feet.	210 feet.
Weight of each anchorage	60,000 tons.	660.000 tons.
Length of each land span	930 feet.	1,500 feet.
Length of middle span	1,600 feet.	2.850 feet.
Size of towers at high water mark	140 x 59 feet.	340 x 180 feet.
Height of towers from high water mark	272 feet.	500 feet.
Height of towers from the deepest foundation to top	350 feet.	690 feet.
Width of bridge	85 feet.	86 feet.
Height above high water	135 feet.	155 feet.
Number of cables	4.	4.
Length of one cable	3.580 feet.	6,100 feet.
Finished diameter of cable	15¾ inches.	48 inches.
Number of railroad tracks	2.	6 to 10.
Grade of bridge	3¼ per cent.	1 5-10 per cent.
Allowable speed of trains	10 miles per hour.	30 miles per hour.
Cost from anchorage to anchorage exclusive of land damages	$5.600.000.	$15,000,000.

THE FALL IN THE RATE OF INTEREST. By GEORGE ILES, New York, N. Y.

[ABSTRACT.]

FACTS regarding the fall in rate of interest. Causes,—approximation to European rates through perfected means of communication, and perception by foreign capitalists that the productive and manufacturing supremacy of the world now centres in the United States, whilst invest-

ments in America are free from risks of war or revolution; that accumulation of great wealth by a comparatively small class has taken place is increase of capital in American hands through rapid development of resources; increase of late years in the ratio of savings offered for investment through increase of savings-bank facilities, building associations and insurance companies; increase of efficiency in production of capital throughi mproved machinery, mechanical and chemical processes; diminution through competition of the rate of business-profit out of which interest is paid.

Effects,—as interest is a lesser share of produced wealth than formerly, wages and rent are larger shares. Facts in proof. Increase in original outlay for railroads, buildings, etc., that expense for maintenance, etc., may be reduced. Rents in the main, a larger ratio of national income than ever, but are less than they would otherwise be since the interest payable on buildings, manufacturing and mining plant, is steadily declining. Accumulation of great wealth by a comparatively small class, who wish to avoid the direct control of investments, has led to a difference wider than ever between the rate of interest receivable on the best securities,— those of the federal, state and civic governments,— and the rate receivable by banks for discounts.

Capital now needs some new form of large investment which will effect some great economy or eliminate some great waste, and provide prime security.

Suggestions: the thorough improvement of towns and cities, as such, by perfecting pavements, sub-ways, means of transportation, etc.; national afforestation, reclamation of arid plains. Brief comment on difficulties in carrying out these projects.

NATIONAL INTEREST IN NATURAL RESOURCES. By Prof. B. E. FERNOW, U. S. Department of Agriculture, Washington, D. C.

[ABSTRACT.]

ALL theories of government agree in its object being the security of society. Logically, this involves also the continued welfare and security of society in the future. Whatever, therefore, affects the future welfare of society must be of present and direct interest to government. Even the advocates of *laissez faire* would recognize the necessity of anticipating dangers rather than wait until conditions become unbearable, before calling for state interference. Continued welfare of society is mainly dependent upon the natural resources. These are squandered; have in many parts of the earth been exhausted or are near exhaustion — examples are adduced — and rational state action in reference to them becomes more urgent. The quality and degree of control by the state must depend upon the relative significance of the resource and the fate it is liable to have

under unrestricted private control. While each individual case must be adjudicated with reference to special conditions surrounding it, a general point of view may be gained from the following classification:

(*a*) Resources, which yield directly necessaries or conveniences of life and form objects of industrial activity.

(*b*) Resources which serve indirectly for the comforts of society or form necessary conditions for industry and progress of civilization, but do not form objects of industrial action.

The former class may be divided again into

1. Resources, exhaustible, not restorable, upon which the so-called extractive industries are based.

2. Resources, restorable, but liable to deterioration under increased activity.

3. Resources, restorable, and apt to yield increased returns to increased activity.

As to state activity with reference to each of these classes, the second principal class falls naturally under direct state control. The same is claimed with reference to those resources which are exhaustible and not restorable. Those which are only apt to deterioration under the wasteful methods of competition require checks of private activity, while in those which yield increased returns to increased intelligent labor, without exhausting the resources, the interests of the individual and state run on parallel lines and call only for the ameliorative functions of the state.

Soil, water and climate are the three principal resources. Society is the natural owner of the soil, but this exclusive ownership does not need to continue, since the fertility of the soil presents one of the resources which is restorable and yields increased returns to increased labor. But to secure the proper appropriation of the soil to productive uses, averting land monopolies, is a proper function of the state. Water and climate, which supplement the resource of the soil and whatever conditions influence them, must be under direct control of the state.

This involves a rational forest management and reforestation of denuded hills; plains and forests which act as such factors upon climatic or water conditions must belong to the state.

Whenever state action is to be based upon theories on the relation of natural forces and phenomena, the conservative theory as the logical one for society should prevail over the radical and destructive one. Systematic procedure in state action with reference to natural resources is urgently called for.

WHAT SHALL WE DO ABOUT SILVER? By S. DANA HORTON, Pomeroy, Ohio.

Who are "we" that are to do something about silver? What are the active forces of which I am to speak? Am I to set forth what I think we, the people of the United States, or of Canada, should do about silver? It

is only at elections that the people can act, in the proper sense, act as one united force, and I am not aware that there is any election at hand. I may, however, say in passing, that if there were elections at hand, I should only need to repeat the substance of certain planks of political platforms about silver which have been actually adopted; for example, by the Republicans in the state of Ohio in 1877, by the National Republican Convention in 1884, and by the Republican and Democratic conventions in New York state in 1885. The first mentioned is a recommendation, while the latter are a ratification, of the policy adopted by Congress in the second section of the act of February 28, 1888. This is not the section compelling the compulsory coinage of silver dollars; it is that by which the United States inaugurated a policy of restoration of silver to its former equality with gold by joint action of nations.

This policy, which by its nature combines the elements of a domestic policy and a foreign policy, has remained since 1878 a settled policy of the United States. I venture to believe it is as firmly in the saddle as the Monroe Doctrine. So far, then, as the United States as a whole are concerned, I shall not undertake the task of making suggestions about anything it may need to do with reference to silver.

Nor shall I ask what the several branches of the legislative powers that be, whether the senate or the house, or this committee thereof or that, have to do on this subject. Nor shall I venture to discuss before you the possibilities that lie before the president or his ministers in this regard. No doubt there are essays to be written which might rightly hope to attain such an audience. But there is no need now to go beyond the limits of this room, or the list of the members who belong here, to find ample work to be done, good work, work of conversion, for the advancement of science, work that all the members are pledged to wish well to. The "we' of whom I speak, then, are the members of the section of political economy and statistics of this Association. I conceive they have something to do for their fellow-men in regard to this matter of silver. The silver question covers something more than a scientific generalization waiting to be proved, a compound waiting to be analyzed, a discovery waiting to be verified—for all these can wait. But the silver question involves a duty to be performed, and to wait is to neglect that duty. Moreover it is a duty which the interpreters of science now living owe it to themselves—to the cause of learning—to perform without delay.

Be it known to all friends of science—and never forgotten—it was science which engendered the silver question with the dangers and anxieties that have come in its train. It was the mistaken learning of 1867, of 1871 and 1873, which did the damage that the settlement of the silver question is to check, and, as far as may be, to replace. It was upon the incital, and with the approval, of an overwhelming majority of the learned of all nations, that the statutes and decrees of silver outlawry in various nations became fact. Americans must take to heart that for this error of policy the United States have their share of moral responsibility, for in 1867 the influence of the American Union in the family of nations was militant in

Paris, aiding and abetting the anti-silver movement then organizing. And all was done with the best intentions, and under the advice of counsel recognized as learned in the law.

What "we have to do about silver," is to educate public opinion and then to advance science, to learn and to teach important truths relating to money —for silver is money and has been since the economic world began—important truths, I say, truths that will assist the present generation of citizens or legislators to safeguard their higher interests by what they do or leave undone with reference to it.

What are these truths? The first truth of all, first because simplest and at the same time universal, *prima inter pares*, is that the policy of federation for equality of the metals before the law—which is the American policy, if our brothers of Canada will permit us, *vis-a-vis* to Europe and Asia, to represent the continent—is right.

I may add in parenthesis that they can the more willingly permit us to do this, since they are in some measure committed in favor of that policy. Such at least was the impression which the highly appreciated ally of the United States delegation, Sir Alexander Galt, conveyed to the members of the international conference at Paris in 1881.

The policy of federation to restore silver to its former legal position, the policy of establishing and maintaining parity between the two halves of the world's money, is right. The union of an effective majority of nations to close a period of disastrous economic conflict and disturbance by a catholic measure of peace and order, is a good work. Once achieved, even a nation may be proud of its share in it. There is enough of barbarism and dulness within sight in our time to serve as a foil in this enterprise of civilization; and individuals who contribute their little quota toward bringing it about need to have theirl abor brightened if not lightened by appreciating the quality of it.

The project passes slowly towards achievement—slowly, for it must triumph over both the prejudices of men and the inertia of nations. But it is progressing, and progressing fast, now at length that the harvest of conversion in England is coming into sight—conversion in England which alone has blocked the way; for in 1881 the attitude of Germany promised her readiness to join with France and the United States in full when England should do so. The time, then, is approaching for realization of the project proposed in 1878, the time when civilization is to make a forward step, reaching a free mint and a united standard.

What the members of this section "have to do about silver" is to recognize, and upon occasion to teach, the basis of truth and fact upon which is reared this policy of federation to secure legal equality between silver and gold.

I shall try to characterize briefly this basis of truth and fact by a rough sketch map, political rather than economic, giving practical generalizations rather than their scientific sub-structure.

I shall offer an affirmative statement on the following lines:—

AFFIRMATIVE STATEMENT.

I.

THAT SILVER AND GOLD ARE THE MONEY METALS, AND THAT GOLD IS MONEY AND SILVER IS MONEY TO-DAY.

Of the above affirmation, I select as the only probable object of denial which calls for encounter, the statement that *silver is money to-day.* Are the members of this section all fully aware of this? I hope they are, but I fear they are not; I fear there are exceptions. I have had the opportunity of meeting, in books or in conversation, the minds of most of the learned of our century who have dealt with monetary questions, and I have found in all that goodly company few who entirely realized—in the subtle yet most important sense in which the phrase is now to be used—that silver is money. This sense or meaning of the phrase springs from the internationality of money; the solidarity of interest, the effective contiguity, or the continuity of the various systems of money (which make up the total money of the world), whereby each has an interest in all, enjoys the lateral support of all, and each serves in part as a means of business communication with the other. There is here a truth which is far from having completed its struggle for recognition. Indeed, the concepts in use to-day in monetary discussion are curiously adapted to veil it from the understanding. What with "Single Standard" and "Double Standard" and "Bimetallism" and "Monometallism," it is singularly easy to ignore the internationality of money. Then again, there is the word "Demonetize." What have we not heard of eloquence about the demonetization of silver, and yet, in spite of this demonetizing devil and all his works, silver is money. So likewise, one might say, for generations men have heard of the conquest of Russia by the great Napoleon—the remarkable thing about which was that it never occurred.

There have been local acts, and partial acts, of outlawry against silver, acts which have done more harm to the erring constituency of gold than to the constituency of silver. But that is all. It is ten years since Germany gave up trying to "make soup out of hot water alone," as Bismarck described it, and abandoned her sale of silver made of melted thalers.

In closing, a word of definition rather than argument concerning the supply of silver. Silver is a money-metal. The annual find of new metal has never been more than a minute fraction of the existing stock. In spite of silver mares' nests, whether in Australia or in the Americas, there is no valid ground for expecting any real revolution in the conditions of supply, nor even that the fluctuations of silver output will equal

Note.—I wish to give notice to any one seeking information touching the measure proposed in 1878, that the document of the Monetary Conference of 1878 is still gratuitously distributed by the Department of State, by mail, upon application to the chief clerk.

those of gold in the past. Hence the stock in existence—that is to say the economic "supply"— is a limited supply; a monopoly of nature not to be broken down.

II.

THAT PARITY OF MONEY IS DESIRABLE.

This affirmation is not unnecessary, as an unbiassed mind might suppose. There are most serious obstacles to logical thinking on this head. The mental vision of our time suffers largely from what I will imagine an oculist calling "atrophy of the apparatus of accommodation," or that there is normal sight, but it is only in spots.

A criss-cross of premium or discount between the moneys of different centres of business is an abomination to the economic mind in every professor's study in the world, provided the places are near each other, as, for example, New York and Philadelphia, or London and Manchester, or Paris and Marseilles. The same truth has vogue when applied to Paris, London, New York, and San Francisco. This kind of organized disorder or Babel of valuations—a financial St. Vitus' dance—is recognized as a grave malady by all regular physicians. Here there is no help but in parity. But how is it with parity between Asia, Europe and the Americas? Here the light grows dim and all signs seem to fail. The lapse of logic is as great as if the regular pharmacopœia should allow its prescriptions to be used only for people in the retail trade.

III.

THAT IT IS THE LAW OF EACH NATION WHICH DETERMINES WHAT IS MONEY IN THAT NATION.

To a public which has passed from state bank notes to silver certificates, it is unnecessary to expand this thesis.

IV.

THAT THE PREPONDERANT EMPLOYMENT — THAT IS TO SAY ECONOMIC "DEMAND"—FOR SILVER AND GOLD IS AN EFFECT OF THE LAWS OF NATIONS.

This is a simple corollary of the preceding. To one who is attracted by the subtleties of causation and of motive, I can briefly suggest two queries. Do legislatures make certain material legal tender because individuals like certain kinds of ornament? Do not individuals choose ornament in part because of the costliness of the material, and of its immediate convertibility into money?

V.

THAT MONETARY LAWS ESTABLISH PARITY.

In establishing money of different kinds or denominations, such laws invariably seek to determine the relation of these kinds or denominations. If they are wise laws they succeed. A law which makes twenty-dollar

notes and one-dollar notes equally legal tender, effects an equation between twenty ones and one twenty. If one denomination were made convertible and legal tender, while the other is neither convertible nor legal tender, the nominal equation is likely to be falsified by a discount on the one or a premium on the other.

VI.

THAT PERMANENT PARITY BETWEEN SILVER AND GOLD IS PRODUCIBLE BY A PROPER REGULATION OF THEIR EMPLOYMENT.

As has been stated, the stock-in-existence—that is to say the economic "supply"—is limited. To regulate the relative "demand" is to regulate their relative value.

VII.

THAT CONCURRENT LAWS FOR LEGAL EQUALITY OF THE METALS IN AN EFFECTIVE MAJORITY OF NATIONS WILL ESTABLISH PARITY OUTSIDE AS WELL AS WITHIN THEIR DIRECT JURISDICTION.

Ample experience justifies this averment. In late centuries the fluctuations of relative value were fluctuations within the range of effective legal ratios. In this century, so long as the mint of Paris was open (before 1873), there has been substantially parity at Paris, and the local fluctuations elsewhere were chargeable, substantially, to "exchange" on Paris. I say "substantially" to make room for dealing fairly with misapprehensions current in relation to this point. Without entering into detail, I will briefly mention that I have discovered the proof that standard gold bullion has fluctuated in London in this century, as against standard gold coin.

If the great powers and their probable allies give legal equality to silver and gold (of course at the same ratio) their parity at points outside of the direct jurisdiction of these nations cannot be prevented (though there may be fluctuations of "exchange") for it is the "law of supply and demand" which operates as a guarantee of the equation.

VIII.

THAT SUCH PARITY BENEFITS EACH NATION BY ASSURING COMPARATIVE STABILITY TO THE VALUATIONS IN WHICH IT IS INTERESTED.

The benefit applies in various directions and degrees in different nations, but there is something like equality in the shares of the nations in this benefit, because of an equality in the ratio of such benefit to the total economic interests of the nation.

IX.

THAT FEDERATION IS A CONDITION AND A GUARANTEE OF SUCH CONCURRENCE OF LAWS.

This natural view, which guided the Government of the United States and afterwards that of France, in approaching other nations on the sub-

ject, is supported by the subsequent inaction of nations. Each is unwilling to move without the other, and it is only accord which will make it safe to break the vicious circle.

X.

THAT THE PARAMOUNT MONETARY ISSUE OF THE AGE IS WHETHER A SETTLEMENT ON THIS BASIS SHOULD BE MADE.

There is no alternative to this settlement, which under the guarantees of federation gives parity through concurrence of laws, but the perpetuation of the evils of that instability in the foundations of business and investment of which mankind has had ampler experience since 1871 than at any period since the Thirty Years War. The mere delay fostered by opposition to settlement creates obstacles to settlement. The opponents of the federation policy are in a double sense friends of disorder.

THE DIS-UNIONIST, OR ANTI-FEDERALIST POSITION.

Those who oppose the growth of opinion in favor of Federation may be conveniently classified as follows:—

First Grouping.

Those who have learned only a part of the truths hitherto set forth.

Those who have refused to learn any of these truths.

Second Grouping.

Those who think the federation project will never be adopted, chiefly because of the expected continuance of England's refusal to coöperate.

Those who think the federation would not maintain parity between the two metals even if England were to coöperate, with free coinage of an English silver dollar.

I hope that my friends in the dis-unionist camp will find nothing to offend them in this classification. One who has been militant, as I have for so many years, naturally attains what I may call a certain perspective in regarding the position of his "friends the enemy," and their Parthian campaign of retreat has been full of instruction. In fairness I may confess that the key-note of what I have been saying was given me by one of the highest names in the camp of the opposition and in the literature of money, for Michel Chevalier is among the prophets for all who have a monetary faith. It was by another anti-silver champion, I should also add, by Esquirou de Parieu, the economic adviser of Napoleon III and father of the Latin Union, that I was introduced to Chevalier. The distinguished author of the first great Treatise on Money said to me, "*You will never get England to join.*"

THE RECEPTION OF THE FEDERATION PROJECT IN EUROPE.

I have said that the harvest of conversion in England is now coming into sight. It is a harvest that took a long and weary seed-time, after a

long and weary breaking of the ground. England was unfortunately busy with other things, and she remains busy. She could not leave Ireland in order to study silver and gold: one might say she could not stop worrying, or worrying about, Ireland, according as one's sympathies are Liberal or Tory. In less troubled times she would have been free more quickly to learn new truths, or rather to recognize old truths in the garb which new experience lends them, and thus would not have blocked the advance of a reform of which she is to be the chief beneficiary.

The advance of opinion in England on the subject presents itself in the following successive stages:—

1. *The attitude of the English representatives at the Monetary Conference of* 1878.—The speeches of Mr. Goschen, at Paris, put the veto of English science and sagacity upon the further rejection of silver money upon the continent. This, logically, was not only an abandonment of the case for England's anti-silver laws, but operated as an admission that the opposite of such rejection, the restoration of silver (proposed by the United States) was a measure which would benefit the United Kingdom. It was an affirmation of the internationality of money.

2. *The attitude of the English representatives at the Monetary Conference of* 1881 was an advance beyond this position. Although promising no further change in the local system of Great Britain than the acceptance of silver as a deposit for Bank of England notes up to the limit of existing statute, to which was added for India the maintenance of free coinage of rupees, the recognition of the interest of the Empire in the policy now proposed by two great powers was made more clearly and more strongly. An analogous admission was contained in Germany's offer of coöperation. As a sequel the silver question was left at England's door. It was plain that under no circumstances could the accession of Germany offer as important a consideration to France and the United States to induce them to establish concurrent free coinage of silver as the accession of England, and at the same time that Germany's adhesion would follow that of England.

8. *The work of agitation and education in England.*—France and the United States not finding that the situation warranted them in restoring silver mintage, it was incumbent upon those interested to set on foot in England a work of education and agitation which should at length secure the desired change in her policy. The International Monetary Standard Association (Bimetallic League) in England, and the Internationale Doppel-Wachrungs Verein in Germany, were founded in the interval between the adjournment of the Conference of 1881 and the date of its intended reconvocation in 1882. Since then public-spirited men have been rallying to the cause from time to time, and the doctrine of monetary union, and parity of the money metals, has been preached in the highways and byways, and in the meantime the evils which we had prophesied have been descending upon England, and have given cumulative force to the teachings of reformers.

I may conveniently mention here a measure of external strategy which

has been amply urged as efficacious for the ripening of conviction in England, namely, that the American Congress should fix a limit to the continued mintage of new dollars. In the never-ending strife in America between those who saw only the silver side of the shield and those who saw only the gold side, the merits of this great stroke for the cause of silver federation have failed of practical recognition. The event has justified the arguments of its advocates. The results obtained in England to-day—the present strength of the pro-silver movement in England—are proof that the fixing of a limit to the mintage of new dollars, under proper conditions, would have acted as the strongest pro-silver measure within the reach of Congress. Failing this reinforcement, the slower processes of education and agitation were continued.

4. *The Royal Commission on the Depression of Trade and Industry.*—An overt act appeared when the Royal Commission on the Depression of Trade and Industry was appointed in 1884. Among its members was Mr. Gibbs, Director and former Governor of the Bank of England, the President of the Bimetallic League. Its final Report was made two years later, in 1886. In its diagnosis of economic malady the disturbance of the money basis of trade and industry was marked as a region which deserved to be explored by a Special Commission.

5. *The Royal Commission on Gold and Silver.*—Such a Special Commission was proposed to Parliament, and was appointed on September 6, 1886. Its Report (presented November 8, 1888), based upon volumes of evidence and exhaustive study by men of distinguished competence, is a memorable landmark in the advancement of science. It is an achievement of moral as well as intellectual dignity. With it the doctrines which many of its members had been wont to hear denounced as heresy, if not as lunacy, have become admitted truths of monetary science. In the limited space at my disposal I will merely mention that the conclusions of the Report afford an ample platform for the education and agitation conducted by the Bimetallic League, and as a specimen I will add an extract from the Report which was signed by the six so-called "gold men" of the Commission.

Part II, Sec. 107.—"We think that in any conditions fairly to be contemplated in the future, so far as we can forecast them from the experience of the past, a stable ratio might be maintained if the nations we have alluded to were to accept and strictly adhere to bimetallism, at the suggested ratio. We think that if in all these countries[1] gold and silver could be freely coined, and thus become exchangeable against commodities at the fixed ratio, the market value of silver as measured by gold would conform to that ratio, and not vary to any material extent."

Note.—The Report (without the evidence) was printed by order of the Senate at the last Session of Congress (50th Congress, 2nd Session) as Miscellaneous Document, No. 34.

Two of the members who signed this report joined in an explanatory note (in which this section among others is referred to) which, without seriously weakening the admission, emphasizes the conscientiousness of it.

[1] The United Kingdom, Germany, the United States, and the Latin Union.

ECONOMIC NOTES REGARDING LUXURY. By A. G. WARNER, Lincoln, Neb.

As national wealth increases it often happens that the spendthrift asks the miser's question, "Shall I not do what I will with mine own?" Numerous answers are given promptly and with emphasis, but they fail to agree with one another. "If the rich did not spend freely the poor would starve," says Montesquieu. "Luxurious expenditure enriches many at the expense of a few," says Voltaire; and he adds, "splendor and pomp are the certain mark of a happy reign: the rich are born for the purpose of spending much." A recent American writer on "Social Equivalents" assures us that "society depends upon and flourishes by the luxurious and extravagant, and even vicious habits and indulgences of its members." On the other hand one might find opinions expressed by a long line of notables from the Hebrew prophets and the Roman Cato down to Emile de Laveleye, which may all be summarized in Goldsmith's apostrophe beginning,

"O Luxury, thou curst by heaven's decree!"

The "apologists" who defend and the "rigorists" who denounce what they call luxury start with different definitions of the term and so manage to justify almost anything they may choose to say, either in commendation or condemnation of it. For instance Laveleye, who says that the "rigorists" are right, makes his position abundantly secure by classing as luxuries only such things as are at once rare, costly and superfluous; and adds that all real luxuries minister to vanity, sensuality or "desire for adornment." More than this he follows Baudrillart in making a distinction between the "desire of adornment" and "love of the beautiful," and so excludes works of art from the domain of luxury. By all these limitations he certainly removes the word very far from the popular conception of it. Only one of the five commodities classed as luxuries in Mulhall's Dictionary of Statistics could be so classed were this definition accepted. Nor does there seem to be any compensating accuracy obtained. When we separate from the "desire of adornment" first "vanity" and then "love of the beautiful," the remainder is much like a globe from which two hemispheres have been subtracted.

On the other hand, the apologists usually define luxury so as to include everything but the barest necessaries of life, and to the term necessary they give a very limited and a very absolute significance. Voltaire urges that if men were restricted to the real necessaries of life they would be reduced,—not merely to the condition of the savage, but to that of the orang-outang. Yet we need not shrink from classing as luxuries everything over and above what is necessary to the life of man; but we must remember that the word necessary is itself a relative, and not an absolute term, and that "the life of man" is more than mere organic existence. A winter trip to the south or a summer trip to the mountains is indispensable to the health and lives of thousands. Subject the inhabitants of a great city to the hardships of a savage life and they would die like sheep in a western snowstorm. Whatever is essential to life as actually developed at a given time in a given place is, within these limits, a necessary of life.

The significance of the term varies according to times, places, races and individuals.

Senior defines "necessaries" as "those things, the use of which keeps a given individual in the health and strength essential to his going through his habitual occupations." This is well put for our present purposes, if only we can make the words "health" and "strength" apply to the mental and the moral man as well as to the physical; for in studying such a subject as luxury it is preëminently useless to ignore all of man except the animal. In the maintenance of the standard of life which a majority of our people have reached, a certain amount of education is not only a "decency" but an essential. Thus broadly interpreting a broad definition of the word "necessary" we find it possible to define luxury as the super-necessary, the non-essential, the superfluous things—material or other, that contribute to the satisfaction of human wants.

What Bonamy Price calls "progressive desire" is the motive power in man's advancement. Savage and barbarous peoples change slowly because they have few wants, and when these are satisfied they settle into stolid indifference. In opening trade with savages it is often necessary to give them the beads, nails, knives, etc., until the desire for such things has developed, and they are willing to purchase. There is an inertia of opinion and habit which often leads people, savages and others, to believe that whatever is new is bad. Yet probably few of those who still join the diminishing chorus that chants the praises of "the good old times" ("all times when old are good"), would care to dispense with table-forks. Nevertheless historians of an earlier date assure us that an eminent Venetian lady was afflicted by Providence with a loathsome disease because she ventured to indulge in such a luxury instead of eating with her fingers. There are said to have been in the whole domain of Charlemagne no articles of linen except two bed-sheets, a table-cloth, and a pocket-handkerchief. In the sixteenth century it frequently happened that a princess made a present to a prince of a single shirt. In the time of Henry IV of France sugar was sold at the apothecaries by the ounce. In making up her tax-list England formerly classed soap as a luxury but now ranks it as a necessity; not only was cleanliness formerly uncommon in Europe but there was organized opposition to it. To the inhabitants of feudal Europe the ability to read and write was a luxury, and as such usually despised; but to the maintenance of the standard of life now reached it is an absolute necessity. Pure air would even now be a luxury to the inhabitants of our city slums, but after they had enjoyed it for a time, it would become an essential element of a better standard of living.

As already intimated, this continual burgeoning of new desires is not only inevitable but desirable. Senior estimates that if the people of Europe were content with the bare necessaries of physical existence that country could support a population of perhaps eight hundred millions; but it would be a population preëminently fitted to suffer much and accomplish little. Europe would simply be overstocked with digestive apparatus—"the more the worse."

Misery is a bad motor for keeping up the economic activities of the race. Rewards stimulate more healthfully than punishments; the industrial freeman works better than the industrial slave. It seems quite certain that Humboldt was wrong when he said that the only way to make the Mexicans more industrious was to cut down their banana trees. On this point Say wisely observes that, "were nakedness a sufficient motive of exertion, the savage would be the most diligent and laborious, for he is the nearest to nakedness of his species. Yet his indolence is equally notorious and incurable. It is observable throughout Europe, that the laziest nations are those most nearly approaching to the savage state; a mechanic in good circumstances at London or Paris, will execute twice as much work in a given time, as the rude mechanic of a poor district. Wants multiply as fast as they are satisfied; a man who has a jacket is for having a coat; and when he has his coat he must have a great-coat too. If he has two shirts he soon wants a dozen, for the comforts of a more frequent change of linen; whereas if he has none at all he never feels the want of it."

Two considerations are urged by the "apologists" tending to show that personal desire should be wholly unrestrained in matters of indulgence. The first is that to limit indulgence is to check progress, and the second is that even wasteful extravagance prevents "over-production," and "creates a demand for labor." This second argument embodies an economic fallacy so often exposed that we need do no more than notice it here. Only when we can believe that a sensible Robinson Crusoe would throw away one umbrella in order to "create a demand for labor" in the making of another, can we believe that a community may profitably consume for the sole purpose of giving a chance for renewed production, or that wastefulness finally benefits anyone. The argument for unrestrained luxuriousness first given is also fallacious. Because all advancement results from the development of new desires, it does not follow that all new desires promote progress, or that all that promote it promote it equally.

Economists have heretofore dwelt chiefly upon the different economic effects that follow "productive" and "unproductive" consumption. But even when the decision is to be made merely between two forms of what is called "unproductive consumption," the present writer believes that the economist ought still to have a word to say, and that the "apologists" are wrong in leaving everything to inclination. Suppose it is a question of properly educating one's children, or of keeping and training race horses. In the one case wealth is consumed in the maintenance of professors and tutors, and in the other of jockeys, "sports" and stable boys. "Some years since it was found that the expenditure for the maintenance of the royal stables exceeded the entire sum set apart for public education in Great Britain." If a laborer has made up his mind to spend ten dollars unproductively it is still a question of importance to industrial society, as well as to him and his, whether he will spend it in a wild debauch or in a health-giving excursion for himself and family. Even from an economic standpoint consumption does not end all; even the "economic man" is something more than a bottomless contribution box.

We have already acknowledged that the "apologists" are right in asserting that progressive desire is the motive power in man's advancement. But it is also our duty to acknowledge with the "rigorists" that it is dangerously easy to advance—down hill. There is one form of luxury that is constructive in its influence on character, helping those whom it influences to a higher and more useful life; but there is also a luxury that is at once wasteful and corruptive. The simplest and most obvious classification of luxuries is into these two classes: those that are helpful and those that are harmful. These two kinds of luxury operate by a common method but towards opposite results; one is an important factor in civilization, the other an important factor in degeneracy. Roscher is right in saying that "an economist who should presume to condemn luxury as a whole would resemble a doctor who should pronounce against nerves in general." Baudrillart says that "the luxury of a healthy society will be healthy, while that of a corrupt society will be corrupt;" and the writer first quoted wisely adds that "diseased luxury is disease engendering."

It is not an easy task to gauge the different kinds of consumption by the standard of human welfare,—that is to sort concrete luxuries according to the classification indicated. Perhaps the very difficulty of the task is the main reason why it has been so long and so unfortunately neglected. The excuse often urged for the scientific neglect of the matter is that the question is a personal rather than a social one; it is said that the only proper guide as to what is right in matters of indulgence must be the instinctive suggestions of each individual's conscience. But it is the duty of science to supplement our instincts and to give them a rational basis. The thoughtless poor agree with the thoughtless rich in believing in the industrial beneficence of extravagance, and their consciences order themselves accordingly. Economics shows their error, and if it can map still other reliable paths through the devious ways of conduct it is a work of immediate and practical importance.

(1) It is characteristic of nearly all helpful luxuries that they are capable of becoming necessaries of life in some higher standard of living, and in default of more definite guide it is often of use to ask regarding any given luxury whether this is true concerning it. Take tobacco, for instance. I suppose it to be true that the more indispensable it becomes to a man, otherwise healthy, the more it injures him. It can thus never become a necessary of life at all, for the simple reason that one's life may at any time become fuller and more complete by merely refraining from the use of it. The tobacco bill of the United States amounts to about $200,000,000—a large contribution to our expenses for harmful luxuries. Of all luxuries essentially vicious it can be said at once that they must always lower the standard of any life they influence. A careful canvass of an American city of 380,000 inhabitants showed that about 20,000 of its people live upon the "earnings" of saloons, brothels or gambling dens. This means that one-twentieth of the available labor power of the city is engaged in undermining its own strength and that of the community.

(2) Lavelaye proposes the following test for determining rightfulness of indulging in a given luxury: Let the consumer ask himself, "Would I,

for the sake of enjoying it, perform the labor that its production costs?" Few, for instance, would wear expensive lace if required to make it themselves. It is frequently suggestive to ask one's self this question, but the test indicated, if applied with any rigidity, has two palpable defects; the first is that it includes in the tale of permissible luxuries things that belong there by no manner of means, and, secondly, it excludes some things that ought properly to be included. It would afford no safeguard against a man's choosing to waste his own labor on that which is profitless. The Indian who trades the proceeds of a winter's trapping for glass beads and red calico, or the laboring man who exchanges his wages for poor whiskey, appreciates most fully the cost of that which he consumes; the thing which he refuses to recognize is its worthlessness. The stock writers on the subject tell of an Italian nobleman who endured all sorts of secret privations in order to keep his box at the opera; and it would not be difficult to give parallel cases nearer home. On the other hand it would be wrong to compel each person to exchange as much labor-time for each article of consumption as it had cost to produce it, because that would gauge the reward of one's own work by the standard of some other man's efficiency. The brain of a great railroad financier, employed (honestly) for a given time, may be worth to industry a thousand times as much as the muscles of a coal heaver employed for the same length of time. All personal indulgence ought not to be reduced to a dead level of equality, and progress thwarted.

In practice, however, this test would be sufficiently well applied could we but insure a just distribution of the products of human labor. It is the universal testimony that a fair distribution of the national resources is the best antidote a nation can find for the poison of corruptive luxury. It is the failure to apply the rule, "if a man will not work neither shall he eat," to the upper, or better to the privileged classes, that has resulted in the most useless and debasing extravagance the world has known. If unearned bread pauperizes the poor, it is no less certain that unearned luxuries debauch and destroy the rich. The most popular labor paper of the present day publishes each week a column of "Society Notes" made of clippings from current periodicals giving two classes of incidents, one illustrating the most pampered and effeminate luxury of our time, the other the abjectest destitution to be found in our great cities. The column reads like a page from the caustic satirists of Rome, contrasting the misery of the provincials with the excessive and vicious indulgences of the Roman dudes; or like a chapter from Arthur Young's travels in France during the closing years of the Ancient Régime. The implication is that, as the privileged classes of Rome exploited the provincials, and the nobility of France the peasantry, so the wealthy classes of our own time are exploiting the laborer; and in so far as this is true it must tend in the modern, as in the older instances, to the increase, not of constructive but of corruptive luxuries. The luxury that springs from wealth unjustly got is twice cursed: cursing the rich whom it corrupts, and the poor whom it impoverishes and enrages.

(3) When we pass from mere suggestion and go behind the market re-

ports to estimate the worth of economic goods in terms of man's welfare, the difficulties are many. Some economists dogmatically insist that they have no right to push their investigations into this field. They hold that the purpose for which economic goods exist is to satisfy human wants, and if this object is attained no further questions should be asked. Yet surely one may properly ask whether, from an economic standpoint, it is well that a given desire should be gratified. If the economists will not try to answer such a question some one else ought to do so. But there is every indication that the economists will not, as a class, shirk their responsibilities in the matter. The "dynamics of consumption" will not be forever neglected.

Suppose one desires to learn the economic significance of the annual consumption of $700,000,000 worth of alcoholic beverages by the people of this country. The conclusions of physiological chemistry must first be noted. Next, the special influence of our climate upon mind and body must be reckoned with. Thirdly, a large number of individual cases must be studied and tabulated in order to determine the exact effect of the drink habit upon "individual economies," as the Germans call them. The budgets of family expenses, collected by the French, German and Belgian statisticians, and latterly by our own labor bureaus, are here available. Fourthly, industrial society may be studied by classes. In some of these it is found that drinking is a consequence rather than a cause of bad conditions. For instance the Buffalo grain shovellers who "trim to the elevator's foot" work under conditions that make the use of artificial stimulants almost indispensable. On the other hand, in many of the better conditioned trades nearly all the acute evils that the workmen suffer, and nearly all the economic wastage that is found seems to come from the abuse of stimulants. Fifthly, we may study the human wreckage of the time, and trace backwards as carefully as we may, the sources of crime and pauperism. A careful analysis of several thousand cases by American Charity Organization Societies gives intemperance as the chief cause of destitution in only about fourteen per cent. of the cases. Dugdale, in studying the "Jukes, "a family of confirmed paupers, finds intemperance a lesser cause of poverty among them than sexual licentiousness. Sixthly and lastly, we may glean some important conclusions from the study of national statistics. Roscher states that when temperance work had been successfully prosecuted in Ireland for a time the annual consumption of brandy fell from twelve to five million gallons. The government revenue from the tax on this article decreased £750,000, but at the same time the production of other taxable articles increased so greatly that the aggregate revenue derived from the country was £91,000 greater than before. Facts of similar tenor are given for some of our states where prohibition has been measurably enforced. From these and similar sources must be gleaned the facts that may at last enable us to determine with scientific accuracy how great a negative factor in our national economy is our national liquor bill.

The laboring population of Glasgow is said to have consumed during later years continually decreasing amounts of milk and oatmeal, and con-

tinually increasing amounts of tea and sugar. The result is believed to be a distinct physical deterioration, one symptom of which is a serious increase in the number of "rickety" children,—those whose legs are too weak to support them. Probably there are other causes contributing to the effect observed, but at any rate the problem indicated is typical of thousands that await solution. Without doubt they belong first to vital science, but their economic bearings also demand study. The recognized agents of production are land, labor, and capital. Man has been less studied as an economic factor than either land or capital. The American economist who has given the most attention to the subject of the consumption of wealth assumes that man is a stationary being; that economic conditions change, but that man is changeless. This is to ignore the most important fact connected with economic consumption. What the man of to-day consumes goes far towards determining what the man of the future is to be; and as his standard of living varies, his influence as an economic factor varies also. The luxuries of to-day become the necessaries of to-morrow, and they deserve at the hands of economists more careful consideration than they have yet received.

THE SCIENTIFIC APPLICATION OF HEAT FOR COOKING FOOD. By EDWARD ATKINSON, Boston, Mass.

[ABSTRACT.]

AT the meeting of this Association held a few years since at Ann Arbor, I submitted a paper as Chairman of the Section, on Science applied to the Consumption of Food. In that paper I treated mainly the statistics of food; in the Supplement I gave the most valuable portion of the communication in the form of various tables prepared for me by Professor Atwater, giving what may be called Dietaries or Days' Rations of different kinds of food, sorted with the respect to the right proportions of the nutrients contained therein, and at various prices for a day's ration. Through this statistical investigation, I have been led to consider the waste of food material through the lack of any true science of cooking. The position then taken as to the relative cost of subsistence or food, as compared to the other necessaries of life, clothing, shelter and the like, has been fully sustained by subsequent investigation on the part of the various Bureaus of Statistics throughout the country. With respect to by far the greater part of the population, probably at least ninety per cent, the cost of the food material, whatever it may be, represents one-half the income of the family. As the income becomes less than the average, the relative proportion of the cost of food material becomes greater. The variation in the price of an adequate day's ration, which I have been able to determine, ranges from about ten cents a day (at which I have ascertained that some poor students caring for themselves have succeeded in maintaining themselves in a fair condition of health, living chiefly upon oat-

meal) up to about one dollar per day expended per inmate, including servants, in a first-class city hotel; the actual expenditure per guest being two dollars each. The average cost of food material per capita fairly corresponds to the sum at which I computed it in my previous address, making allowance for the reduction in prices since that day; viz., somewhere between twenty and twenty-five cents per adult for each day's portion. The lowest terms on which large numbers of persons are subsisted according to their own standard of comfort may, I think, be found in some of the larger factory cities of New England, where meals are furnished to operatives known as "mealers," being those who do not live in the factory tenements but at some distance from the factory and who take their meals in the factory boarding-houses; these mealers are now furnished with twenty-one meals per week at a cost to them of $1.60, and at that price the purveyors make a profit. Yet even on this average of the cost of subsistence computed at twenty to twenty-five cents per day omitting the very lowest, there is a great waste which I think may be attributed to the want of any true science in the application of the art which lies at the very foundation of cooking; to wit, *the application of heat to the process of converting crude or raw material into a suitable and appetizing form for nutrition and digestion.* On the whole, it may be said that the whole practice of the art of cooking in this country is distinctly wrong, tending to destroy both the appetizing and the nutritious quality of the materials which are used in greater or less measure, and to promote dyspepsia to the utmost. The wrong direction is due to the attempt to cook almost everything quickly. The stoves, whether coal or oil, which sell most freely and readily are those which can be recommended to do their work in the quickest way and that is generally the wrong way. On the other hand, the very art of fine cooking and the skill of the skilful cook consists in the application of heat at the right degree and for a suitable time, according to the kind and quality of the food which is to be converted.

Without claiming any but the merest superficial knowledge of chemistry, nutrition and physiology, I venture to present the subject.

From my own experience I have reached the conclusion that the flavor which is desired in many kinds of food is an actual *product* (if we may use the word) developed in the process of preparing the material by the application of heat. For instance, if we grind the green coffee berry and attempt to make an infusion from it, it utterly fails in producing what we call coffee; if the coffee berry is burned in place of being browned or roasted by heat, and the infusion is then made, it is acrid, unpleasant and probably injurious; again it is not coffee in any true sense. But if the right degree of heat be applied for the right period of time so as to produce a uniform result, the coffee then being ground and the infusion made, we have true coffee. Unquestionably this flavor of coffee is developed by the chemical change worked by the action of heat. I find the same treatment to hold with respect to the treatment of grain, of fish and of meat.

Raw meat is unpleasant to the taste or flavorless; when baked in the common way in stove or range at a high heat (the precise degree of which

is almost unknown) it fails to attain its true flavor, gives off offensive smells, and becomes in part indigestible by the "cracking" or change which is effected in animal fat at a high heat; but if meats are cooked slowly at a degree of heat below that which cracks or dissociates that portion of the animal juices or fats which is volatile at a high heat, the flavor is fully developed as well as the nutritious properties; no offensive smell is given off in the process and when such meat is re-heated it has not the unpleasant tang or greasy taste which is developed in meat cooked at a high heat, when heated over again.

The flavor of fish is yet more fully developed by cooking at a moderate degree of heat, less than that at which the fat or juice of the fish is dissociated or distilled.

With respect to bread, the contrast is as great or greater; if bread is subjected to a high heat, being composed almost exclusively of starchy or carbonaceous material, the crust is almost immediately formed; this crust becomes a non-conductor of heat, and if the bread is subjected to this high heat long enough to cook the middle of the loaf thoroughly the crust is burned. Every one is familiar with the ordinary condition of badly-cooked bread, the middle being indigestible; the yeast plant not being killed goes on fermenting; the nutritious properties are not fully developed; and when kept the bread dries up quickly or molds as readily, according to the condition of the atmosphere.

I find that if I subject bread to a heat not exceeding 250° to 300° F. for twice the usual time, a tender crust is formed while at the same time the bread is cooked to the very heart of the loaf. It has a finer flavor than the ordinary bread, and may be kept for a week under ordinary conditions of the atmosphere without drying up or becoming mouldy.

The missing science would therefore seem to be the right method of applying heat to the conversion of food material into digestible and nutritious food.

The first rule in the development of this science, or in the art of cooking, must therefore be *to catch your heat*, to put it into the oven, and to retain it at a normal or given degree of heat adapted to each kind of food for any length of time. As a matter of course this cannot be accomplished in the ordinary cooking ranges or stoves. Coal or wood cannot be burned under ordinary conditions so as to be readily controlled; a greater or less proportion not only of the unconsumed gases but of the heat generated will go off through the chimney; while the materials of which the common stove is made, permit the heat to escape and to diffuse itself through the room perhaps in very much larger proportion than that which is retained and converted into work upon the food.

The necessity of the case therefore calls:

1. For the perfect combustion of the fuel so that no chimney may be required to carry off the waste products.

2. An oven in which heat may be maintained at any normal degree required for a given number of hours under quick and easy control.

All this has been accomplished in a somewhat crude method in the cook-

ing vessels which I have named Aladdin Cooker and the Aladdin Oven. I had hoped and intended to be present at the meeting and to perform some experiments, had circumstances not prevented; and I will therefore give a short description of my apparatus.

The Aladdin Cooker is a development of the Norwegian cooking-box, with an attachment thereto, corresponding to the water-back of a cooking range or cooking-stove. The box being made of pine, or of pine slabs filled in with sawdust, about one and one-half inches thick, is lined with metal; from one side project two pipes one above the other. To these pipes a conical heater is attached through which water circulates where it may be subjected to the heat developed from the top of a chimney of a common kerosene lamp; the water may be made to boil by the use of a powerful lamp, or it may be kept for any length of time at about two hundred degrees. Many kinds of meat and of grain can be thoroughly and nutritiously cooked at less than two hundred degrees if subjected to heat for a sufficient length of time. This apparatus has been used by many mechanics who are obliged to get an early breakfast; they can place in porcelain pots portions of meat, fish, oatmeal or corn meal, put them into the cooker, light the lamp, and leave the process of cooking going on through the night. In the morning a nutritious breakfast is found to be ready without any further preparation.

The *Aladdin Oven* consists of a case made of properly prepared wood-pulp framed in a metal lining which constitutes the outer oven. The walls are made from one-half inch to one and one-half inches thick, according to the size of the oven; a round opening is left in the bottom (the bottom being made wholly of metal) through which the heat from the lamp passes. Inside and set off from this outer oven is an inner oven in which the food is placed which is to be cooked. A ventilator is at the top of the oven communicating with the inner oven, but it is seldom necessary to use it.

In this oven, broiling can be imitated in a way which many prefer to the regular method; roasting can be accomplished in perfection; also baking and braising.

The heat must be in proportion to the lamp or lamps placed under the oven. My experience has extended from single pounds of meat or small birds, to sirloins of beef weighing thirty pounds, turkeys and geese weighing seventeen pounds; and so on.

By the use of a lamp of the Rochester type, in which the consumption of oil is perfect, about sixty pounds of food can be thoroughly and nutritiously cooked in four charges, with the use of only one quart to three pints of oil burning from eight to ten hours.

These inventions are crude, but they lead the way toward the right system of building stoves; viz., with non-conducting jackets so as to hold the heat which is imparted by the perfect combustion of the oil or gas which may be used as fuel.

There may be gentlemen present who can bear witness to the appetizing quality of the dishes which I have put before them. I regret exceedingly that I could not be present to give a taste, at least, of the product of my ovens to the members of Section I.

FOOD MOULDS THE RACE. By MRS. NELLIE S. KEDZIE, Manhattan, Kansas.

IF Abraham is called the Father of the Faithful, then Sarah, the princess, who took fine meal and prepared food for the three wanderers, is the mother of a princely line of hospitality whose dainty hands have fed angels unawares in all ages.

We speak of men and their deeds and seek to explain their careers by saying "they come of good blood;" but whence comes good blood save from good food, the literally "circulating medium" of life.

The human mind, no less than the body, must grow and develop: while all admit the simple fact that the body is sustained and developed directly by the food eaten, it is as fully conceded that mental growth is dependent upon proper physical nourishment. And no question will arise when it is asserted that neither mental, moral nor physical growth will be full and general unless the food be what is needed as regards quantity, quality and digestibility. Character is moulded by each day's living. Every meal eaten has an effect upon the moral nature as well as the mental and physical.

Animals living upon flesh are those of fierce, eager energy, daring, cruel, masterful, but gloriously successful in living the life of war their physical courage makes possible. The herbivora are peaceful, teachable, tender with each other, but lacking in the courage, ambition and energy characterizing those animals of carnivorous habits. Playfair says this is noticeable in the same species, and asserts that the bears of India and America, living upon mast, are mild and tractable, while those of the polar regions, feeding upon a meat diet, are savage and untamable.

Man eats all food; so we find all traits of character developed. One may counterbalance another. Another may predominate. However much we attribute to heredity, we must concede that food, the building material of the body, will to a great extent determine the structure; and habits, tastes and thoughts are largely the results of bodily cravings. We conclude, then, feed a child properly and he will be the man sought for. To a certain extent, this is true. To how great an extent is yet to be learned.

Many nations of the earth depend each on some staple for diet. Who shall say the Chinaman's rice, the Greenlander's whale blubber, the Sandwich Islander's fruits, or the buffalo meat of the American Indian has not been the source of the traits we find so prominent?

Our own nation stands to-day with its working classes superior to those of any country on the globe. The laborer has better pay, enabling him to live upon better food. The German, the Swede, the Bohemian, who comes to this country and lives upon the food common on American tables, soon shows the difference in diet in his increase of mental and physical ability and endurance. This is especially noticeable in the housework girls and farm laborers. While the increased facility for learning is of some import, the change in food is easily seen. The different climate makes a change in diet necessary if growth be kept up. The climate of the United States, where the clear dry air develops fruits of firm flesh and aromatic

flavor, gives to its people a more "high-strung" nervous organism, and for this they must have a higher order of food. We find this accomplished by the eating of meat. It is doubtless true that nitrogen is conducive to growth in brain power, and Leibig believes that the rich nitrogenous diet of English-speaking people is the real source of their indomitable energy. The people inhabiting England eat an average of four and one-half ounces of meat per day, while just across the Irish sea only two and one-half ounces per week is the average. What wonder the Irish have grown rebellious, suspicious and lawless? A hungry man is an angry man, and in spite of his ten and one-half pounds of potatoes per day the Irishman gets but little of the element we believe necessary to vital force, for potatoes give only three-tenths of one per cent of nitrogen.

Whether meat is the needed substance, or whether nitrogen can be supplied in some cheaper or better way, is not the only problem to be solved. Cheapness in food may become a great wrong. When food is too cheap, labor becomes cheap in proportion, and the value of life is lessened because so great an amount of human strength may be bought for little money. With the wages of our country, the average American poor man is well enough provided with the money to buy the necessary amount of food. The great want to-day is ability to properly prepare that food so it shall do for him what he needs done. One pound of beef should give one hundred and eighty-four grains of nitrogen; but suppose it be fried in grease until it becomes so tough and hard no digestion can assimilate it? A date is more than half sugar, but if it be not palatable to the eater, it may not digest at all, and a strawberry, though it be eighty-seven per cent water, will give more nourishment than the unassimilated date. Only that portion of the food which is digested and used by the body can be of any value. Food taken into the system, must, in some way, be disposed of, and if of no value it is worse than useless, for it requires force to dispose of it; and this unnecessary expenditure of force, bringing no return, weakens the structure quite as rapidly as honest work which brings full compensation.

There is too little known of the real values of foods, and less is known of them in the different states we find them when cooked well or ill. The chemistry of to-day gives much toward a comparative knowledge of the food value of many substances, but these values are very vague when it comes to the question of practical worth. It is not enough to know that a dish of food contains enough of the requisite elements to give strength for a certain piece of work. If that food be not easily assimilated by the system into which it is taken, or if it require too much vital force to be properly digested, it becomes worthless; or worse, a drain upon vitality.

It is not enough to know that a pound of food ought to give certain growth or strength; the knowledge of the best method of preparing that food in order to obtain from it all the benefit possible is absolutely essential. If all people were simply machines which would digest all foods alike, and if all cooks made all dishes exactly alike, some definite results

might be obtained. Realizing that the average adult must have 4100 grains of carbon and 190 grains of nitrogen for subsistence diet every day, the next step would be to know just how much carbon and nitrogen will be needed to hoe the garden or sweep the floor, and the calculation for each person's meal may be made on that basis. However absurd such an idea may be, it is only an extreme of what every good house mother does to-day. In planning her three meals, she prepares more meat for the worker, be he of brain or hand. The carbonaceous foods represented by the fats and heavy sweets, she saves for winter use, when the outside cold is to be combatted; while the dainty dishes, made up mostly of cold, do their share toward mitigating the heats of summer.

The selection of food and the preparation of the meals form a science the depth and importance of which are just dawning upon us. The influence exerted in a home may be very materially affected by the food upon the table. The laboring man who has in his home an intelligent wife who prepares the food he needs to nourish his body properly is seldom the man who depends on tobacco for nerve force, and who ends his day over a beer mug. The merchant prince whose dinner is ordered with thought for his work, for his physical and mental needs, is seldom the man who lingers over his winecup, or who goes to the gaming table. A well-fed man is a contented man, and plenty of the right kind of food is one of the potent forces against all crime.

Crime of many kinds is urged upon members of an enfeebled race by bodily cravings which years of proper food would do much toward removing. So much strength has been wasted in attempting to utilize food of insufficient nutrition, or food which is not easily digested, that the system, being thrown out of its normal state, is unfit for healthy work and thought. Many of the grave questions of the day would dwindle into insignificance if every woman in every home knew how to best prepare the food her husband earns so that it would give to him the kind of strength needed for his work. If the table be rightly managed, the several appetites, as well as the several kinds of work, must have consideration. "What is one man's meat is another man's poison," and earnest study, faithful thought, and careful judgment are demanded of the woman who is a success in her home.

A nation is made up of homes. The homes make the men who are the nation. The manager of the household is the one upon whom depends, to a great extent, the strength of mind and body developed in that home.

Knowing this as we do, it seems strange that in the plan for the education of our girls we have neglected to prepare them for the one position in life which they are almost certain at some time to be called upon to fill. Every woman, be she rich or poor, mistress or maid, has need to know what to cook, and how it should be cooked to bring desired results. While every housekeeper takes some thought for the needs of her household, she takes that thought with true discretion, only after years of experience. When our first parents left the garden for the homestead in the country, we are told, "The world was all before them, where to choose their place

of rest, and Providence their guide." All the ages since, when the inexperienced bride enters her Paradise of wedded life, though she has a great world of cookery before her, she has sore need of a Providence to guide her choosing, if her husband escape dyspepsia, and her happiness be complete. There seems very little in the way of helps for a young housekeeper. She must learn to feed her family by hard experience. As our nation proves its strength to-day, all honor to the women of the land who have so well learned to make bricks without straw!

The larger half of humanity eat too much and digest too little. The greater part of the food on American tables is only in part the food it might be, because of inferior preparation. When one of the essential studies in all schools is on the selection of foods, and when all our women are taught the proper preparation of foods, then we may look for radical change in the condition of the poorer homes of the country.

A girl needs to be taught carefully and thoroughly for her life work, and there is no way by which the art of cooking may be taught except by actual experience. No one can learn this art from books. As well think of sending out an accomplished piano player by giving her plenty of well-written music books! No amount of talk can tell one just how long to knead bread to always arrive at the same result. No amount of experiment can give an exact rule for amounts, or weights, or heat, or time, in order to reach precisely the same end. Conditions are so varied that while general principles can always be depended upon, much judgment and some practice must be elements of every dish compounded, or sometimes, a dismal failure will be the result of the cook's efforts.

Every girl has a right to some preparation for her future years! Every teacher needs to implant in every child's mind the thought of the importance of knowledge in the selection of foods, their values as regards strength-producing elements and digestibility. The individual taste as well as the individual needs, must be consulted in this selection.

We are doing something toward giving our women some of their rights in this direction. Whether it is to be wise to bring cooking into the public schools and teach it as certainly as we teach grammar, is an open question. The one study is surely as important as the other! Or whether special schools for teaching the art will be the future rule, time alone can tell. Practical cooking must be taught, and the women of the land must learn to cook wisely and well!

Whether the preparation of food in the future shall be done in the individual homes as it is done to-day, or whether it will be managed on some coöperative plan, it will still be essential that the person who carries the responsibility of the food shall know what is to be cooked, how it is to be cooked, when it is to be eaten, and by whom. Then results will be known, planned for, and attained. Then will our nation be truly blest, for her women will look well to the ways of their households, and "their children will rise up and call them blessed!"

How shall we protect our forests? By R. W. Phipps, Toronto, Ontario Forestry Commissioner.

In answer to the question, I will mention the different methods which appear to me most feasible.

Arousing public opinion.—Each State or Province should employ a competent official to obtain information on the subject, and circulate it by means of pamphlets generally called Forestry Reports. With these, two things are advisable; first, that they be written in an interesting style, for mere dictionary statements on the subject would simply be left unread; next, that they be widely distributed, and among proper persons, not merely sent to officials and prominent men, on whose shelves they are likely to remain untouched. An excellent method is that of obtaining, from some well-informed person in each locality, the names of all he knows likely to read with profit such a book, and sending one by post to each on his list. In addition to this, it will greatly aid if the forestry official be able to address, during each year, many communications to the press throughout his State or Province. In addition again, addresses delivered at many points each year will be found of great service.

Free distribution of trees.—Young saplings, obtained in the forest, are very inferior to nursery-grown plants. The forest-sapling has generally two or three long roots, which cannot be obtained in full extension, or carried or planted if they were. They must be cut, and the chance of growing risked. Then, many of them are grown in the shade, and will not stand the open sun. On the other hand, the nursery sapling, two or three times transplanted as it should be, gets a more bunchy and fibrous root each time, and naturally grows far better when placed in its ultimate position. Very small trees, especially evergreens, can be, indeed, and often are, taken from the forest, and planted in the nursery, when, after two transplantings, they have excellent roots. But when obtained from seed, or when young from large nurseries, the work is far more easy and certain. When one goes for trees to the bush, though saplings apparently be countless, it is surprising what trouble it will take to find what is wanted, and to get fair roots then. Again, in our settled country, where cattle are often made so free of the bush, young trees are hard to get in any case. For all these reasons, if the farmer had available, when he was ready, some thousands of good, well-rooted, healthy saplings of the kind he wishes, he would often be willing to plant and care for them. Therefore, I consider that a large public nursery, where trees might be obtained free of cost, would be one of the greatest inducements to land-owners to plant. It will not do to say that he who wants trees should buy them. There is an inducement needed here, or the work will not be done. The work is national; it is the nation desires the farmer to plant the trees; it was the fault of the nation that he was ever allowed to

obtain public land at first without an agreement to retain a certain portion in trees. I have now, for seven years, been examining this subject, and I am strongly of the opinion that under a system of free saplings twenty times as much planting would be done as at present. Instead of free nurseries, governments sometimes give grants of orders on nurserymen. With careful and earnest supervision, either plan would answer. The great point is—free distribution of young trees.

Settling fresh woodland.—The great error of the original settlers was taking hill and hollow, mountain and valley, indiscriminately, for settlement. The result is that many mountain tops were cleared, farmed, and ruined, for the soil washes away, and in a few years nothing remains but to desert it, and go elsewhere. That the mountain should be wooded and the sloping valley cropped is the very A B C of forestry, and this should be secured by saying to the settler, "You cannot have such a lot; it is a mountain top; it must stay in wood; and if you take such a lot, you must agree to keep such a part in wood, and to keep cattle out." This may seem harsh to the settler; but in the end it would be far better for him. If there is one lesson more than another which over-clearing has taught America, it is that people should not be allowed to enter the woodland to hack and hew as they please. There are now millions of acres of deserted and worn-out farms, in the Eastern States and Canada, which were simply the elevated ridges fit, with care, to bear timber for ever, but not fit for farms, as the earth washes off. It is hard for the settler in a forest to know the elevation, but the survey should have regulated matters. I wish it to be understood that here I speak from my own experience; when over thirty years ago, with no one to guide us, many of us entered the forest, we cleared much land that never should have felt the axe, and is now worthless, or very near it. This is not proposed in the case of the ordinary rolling land of the country, nor where there are a number of small hills. But where thousands of acres form the watershed of a mountain range, they should remain in wood.

Forest reservations.— Forest reservations, of twenty or thirty miles square, should be left at those places, found in most countries, where the sources of many streams arise, that the rivers, which pass thence through the rest of the country, may be preserved. These will form reserves, where timber may grow, to be thinned, not cleared, at maturity; they will also give shelter where birds and animals, otherwise in danger of extirpation, may still live; and, as the country around is cleared, they will be invaluable for summer resorts. These would, if cared for, remain beautiful remembrances of the pristine forest, full of sylvan glades and delightful groves, retaining the undergrowth, the wild flowers, the deep leaf bed, the pleasant freshness of the virgin forest. In this state they are most valuable preservers and distributers of moisture. But if left without care, fire will here and there burn the hills to the barren clay, cattle will destroy the undergrowth, and the whole scenery appear dry and desolate, compared with what it was, and might still have been. Two

things, then, are here necessary: prevent settlement there, and appoint care-takers.

Remission of taxes on woodland.—It would greatly assist in preserving a considerable amount of forest throughout the country, if taxes on woodland, where the country is sufficiently cleared, were in all cases remitted, and if, in the same connection, some stipulation were made that cattle should, to a proper extent, be excluded, very great benefits would follow. For it may be here remarked that a wood dried up and hardened — its undergrowth destroyed by cattle — is of very little value climatically, compared with one where the forest bed is preserved. Neither will it remain a store of fuel, for, there being no young trees, the forest must ultimately die. There is no doubt, however, that many of these wood lots are allowed to decay, because it is intended to clear them up, and that, if the remission of taxes induced the owners — as it in most cases would — to keep them as permanent forest, much better care would be taken of them.

Tree claims.—In prairie countries, sections of land have been given free to settlers, on condition that a certain number of acres, generally ten, were planted with trees, and kept in good condition for a certain period. This has been tried for years in the States, but many frauds are said to be perpetrated under it. I have myself found, when at the great private nurseries in the west, where the young trees were procured, that it was always a practice to purchase the worst—the culls, in fact, for tree claim lots. The system was nevertheless valuable, but needs to be carried out in good faith, by competent and firm inspectors. The prairie lands, both of Canada and the States, urgently need tree planting, and will give good returns. Plantations of miles square have been grown these eight years in Kansas by railroad companies, and with good paying results. Yet, even with this successful example before their eyes, settlers plant little. When I saw them they were four and six years old, yet still the prairie for hundreds of miles was comparatively treeless, though all admitted the benefits of trees. I should recommend, in prairie countries, while the soil is yet in government hands, that many millions of young trees be planted and cared for under government appropriations, cultivated to keep down weeds for a couple of years, and the prairie close by ploughed to prevent fire running to the trees. In this we should not wait for experiments long. It is necessary to plant four times as many trees as needed, to allow for thinning, and by planting different varieties, it would be easy so to arrange them that even if three-fourths failed, we should still have a fórest. But three-fourths would not fail. This would cost millions of dollars, it is true, and it is equally true that it is a matter in which, above all others, millions should be spent. If, when I first saw the prairie States, between thirty and forty years ago, an appropriation of ten millions of dollars had been given to plant trees and care for the groves then existing, these States would, I am well assured, be more valuable by a thousand millions of dollars now. Can nations not afford such

sums? Let us think of the sums they are without exception ready to spend in war, and then answer. But that, it may be said, is to preserve national life. So is the other. Every well-informed student of history is aware that in all the past, as the forests of a country were destroyed beyond a proper proportion, national life weakened, and by the time when, as examples show us, the treeless desert had overspread the ground, the nation was dead.

Preserving timber forests. — The preservation of these has been little thought of in America, and the lumberman, on condition of paying the authorities a certain amount, has been too often allowed to cut at his pleasure. No care has been taken to replant forests. In Europe, on the other hand, the wood-buyer is carefully instructed as to what portion he may clear or thin, while, as soon as the ground is ready, it is again planted, or the gaps filled. Two reasons for the American practice existed: first, farm land was needed. This reason is not now valid, as the pine land now left is very largely too poor for agriculture. Second, and chiefly, the timber could be sold. Matters have now come to pretty much the following condition. This generation, say for thirty years, will have timber enough, though they will have to use much wood hitherto thought unfit. After that, there will be little good pine and not much good hardwood in our present forests; what is obtained will be brought from British Columbia and the forests of the Southern States, while the generation following will exhaust these. Considering the well-known benefit of keeping a large section of the country in forest—benefits which it is not the province of this paper to state—I would earnestly urge the people of America to consider how much more advantageous it would be at once and decidedly to say of certain large portions now in forest, "These shall not be cleared for settlement—these shall be sacred to the tree." Once this determination is arrived at, the rest is easy. Nothing is more simple than to introduce and maintain a method of forest preservation, if populations demand it, and governments fulfil their desires.

It is often said, "We have a large proportion of forest land." But most of this is not good forest. Much has been overrun by fire, much culled of every good stick by the lumberman. But nearly all of this might be renewed, and made good, permanent forest, if the means were used.

Means used in Ontario.—I will close this paper by stating what is done in Ontario for forest preservation. Much forestry literature has been for years circulated by the local government, and with good effect. A money bonus, half paid by government and half by the township, is given for the planting of lines of trees, in good condition after three years, in every township which chooses to adopt the law. Over fifty rangers, half paid by government and half by the lumbermen, are kept in the woods during the summer months to prevent fires—a very valuable measure. An Arbor Day is also yearly held, with excellent results.

Finally, the answer to the question, "How shall we protect our forests?" is "Spend more money in their preservation, and be less eager to make money by cutting them down."

CERTAIN ASPECTS OF AGRICULTURE IN THE ARID REGIONS. By J. RICHARDS DODGE, Washington, D. C.

[ABSTRACT.]

THE soils of the arid region are generally fertile to excess. Depletion of valuable elements, rather than accretion, tends to their improvement. Humus is comparatively deficient, but carbonaceous matter can readily be supplied by the roots and stalks of rankly growing plants. Thus their amelioration is practically dependent upon one contingency, requiring only the application of water, with mechanical disintegration by suitable methods for reduction to necessary tilth, and the chemical changes which occur naturally in the cultivation and growth of plants.

The great plains which constitute the eastern slope of the Rocky mountains are not level, as they decline eastward from four to five thousand feet in five hundred miles, or eight to ten feet per mile, a scarcely perceptible slope, especially in comparison with the minor undulations of the surface, the "divides" between the streams and valleys which collect the superficial drainage waters, the "draws" which carry the storm waters to the creeks and rivers, and something of the irregularity which obtains in more eastern regions sometimes designated as rolling prairie.

A large proportion of the soil of these plains, which appears on the surface to be gravel from the loss of its finer particles by the perpetual winnowing of the winds, exhibits a marvellous transformation when inverted by the plough, a rich brown or other dark color, breaking readily into fine tilth, easy of cultivation after the first breaking, which requires two pairs of good horses for thorough subsoiling. The sturdy homesteaders, who understand the advantages of thorough cultivation, while laboring under a scarcity of teams, increase their power by supplementing a pair of horses with oxen, even training cows to the service when necessary.

These plains, seen in the day of the Indian and the buffalo, burning in the glare of the noonday sun, brown and sere with a scanty covering of drying grasses, flecked with prickly patches of cactus green, present a strange but not disagreeable contrast with fields now seen by thousands, golden with the ripening grain, purple with a sea of waving blossoms of the alfalfa, or green with the leafy vines of the potato which hide from view the first glimpse of the brown soil which they shade and cool and moisten. And yet a single year suffices to change the desert to a garden.

The magic word which effects a change so sudden is *water*. This is the only essential element that is deficient and to be economized. It is available, first, in the precipitation of rain and snow; second, by irrigation from waters at present obtained through the aid of engineering and the use of capital usually impracticable by a single farmer; third, by waters to be collected by storage reservoirs in the higher elevations; fourth, by catch basins throughout the entire plains area for saving the surplus storm water; fifth, by pumping from the underground channels beneath the bed of the streams which are nearly or entirely dry on the surface; sixth, by the expensive and restricted (if not uncertain) means of artesian wells.

These methods are all in successful operation except the proposed reservoir system to be undertaken by the government, though the artesian plan has a very restricted operation, while its extension is active at present. Several millions of acres are already reclaimed, or rendered more productive by the application of water. In Wyoming, water has been taken from about four hundred water courses, through more than two thousand ditches, irrigating a million and a half of acres. Colorado is able to make a still larger showing, with results in agricultural production that are claimed to surpass in value the output of mineral wealth of that prosperous state. California, by the aid of irrigation, long since placed her agricultural products at the front of her magnificent display of wealth in annual production. Montana, Idaho and Utah are advancing in improvement with great rapidity, through the distribution of their stores of running water. Arizona, Idaho and New Mexico have less abundant resources developed in a less degree.

In the application of water there is much waste, in the seepage of canals, and in passage through soil and subsoil of much of the water applied to the fields. This surplus finds its way to the stream from which it came, and can be drawn out a second time by new irrigation works at a lower level. This has been done notably on the South Platte, in the vicinity of Fort Morgan, where thousands of acres are under irrigation, with an abundant supply of water, though the South Platte, above Denver, and Cache le Poudre, above Greeley, have been drained nearly dry to refresh the multitude of farms and gardens of those higher levels.

It has been suggested that the quantity of water required would become less and less, after modification of the soil by long cultivation. Though the first saturation of the soil requires an amount of water which is not necessary for the second, and its hygroscopic condition is greatly improved by repeated applications, the current experience in irrigation does not exhibit a continuous reduction of the supply to the vanishing point, so that practically a limit of the "duty" of water prevents the annual enlargement of the irrigable area. In ordinary usage the application is not frequent enough to keep the soil so moist as to lessen materially its capacity for moisture.

After all available water has been obtained, by these various means and expedients, there is still a large part of the superficial area that must remain unirrigated, possibly five-sixths, probably not more than nine-tenths of the northern and central portions of the arid region, while in the southern the proportion may reach nineteen-twentieths. In the entire breadth of the territory designated as arid it is probable that all available waters will scarcely suffice to reclaim and fertilize one-tenth of the whole.

Yet the remainder will not be quite a desert. There are what are agriculturally designated rain belts, where sixteen to eighteen inches of water, sometimes twenty inches per annum, are found to produce good crops of corn up to an elevation of 3000 to 4000 feet, and wheat, oats, potatoes, alfalfa and many grasses up to 6000 and 7000 feet, by adaptation of methods of culture to the best utilization of available moisture.

Thirty years ago half of Kansas and Nebraska was believed to be hopelessly arid, useless for purposes of agriculture, though of some value for its scanty pasturage. It was so reported by hunters and explorers, men of business and men of science as well. Their view was superficial, their data for generalization incomplete; agricultural meteorology was then in its infancy, as indeed it has not yet arrived at its years of mature discretion. There are evidently yet powers and principles that are not dreamed of in its philosophy. The one hundredth meridian, then assumed to be the limit of profitable agriculture, has become the centre of one of the finest corn belts within the national area.

The extension of homestead entry and settlement has gone on beyond this imaginary line. without regard to the dictum of the practical sense or science of former days, breaking prairie, planting crops and growing timber. It has pushed its way westward, driving the cattle of the range before it, sinking wells, building houses and barns, on through county after county, and stopping not at another barrier, the imaginary line separating those states from the great mountain desert area of Colorado. Here the elevation has risen to 3000 feet or more. Still there is a rainfall of about fifteen inches, and the adventurous settler dares to file upon the lands of eastern Colorado for purposes of settlement and cultivation under the homestead law. Now the enterprising people of the Centennial state are claiming the existence of a rain belt in Colorado, and her most intelligent publicists are claiming, for the rain belt production in agriculture in 1889, one-third of the value of all the agricultural products of the state.

Thousands of new farms are annually taken up in this belt, which is held to include all the eastern counties, from north to south. It also includes the grand divide between the South Platte and the Arkansas, a ridge stretching eastward from the mountains, from an elevation of 7000 feet which gradually falls off towards the east, as it does more precipitately towards the north and south.

The still higher mountain parks, while liable to frosts, and therefore useless for a wide range of agriculture, are valuable for hay production, and capable of producing oats and potatoes on their lower levels.

Most of the homesteads of the "rain belt" have been established within three years, and are promising and flourishing at the present time, the season having been unusual in its rainfall. Last year was one of drought, which tested the perseverance of settlers driving the more tender of the "tenderfeet" class back to the eastward, yet most of them remained, while the more diligent and practical secured ample crops. In one instance, a few weeks ago, I saw a crib of corn, which was a part of a crop of eight hundred bushels grown on a homestead in the unfavorable season of 1888, recently taken up and cultivated by a man nearly seventy years of age. Others in the same vicinity grew fair crops of corn and other cereals, potatoes and hay, notwithstanding the absence of rain after the scanty precipitation of early spring.

How are these results accomplished? How is the change produced, from apparent barrenness and desolation, to bountiful productiveness, to a scene

of rural beauty. It is the result of utilizing the rainfall which was formerly wasted, and the unexpected efficiency of that limited resource, together with the power of man to adapt his methods in industry to unaccustomed conditions, to adapt the processes of agriculture to overcome the limitations of partial aridity. The practice most successful and popular, under these conditions, is found in deep ploughing, with subsoiling, turning the surface soil six or seven inches at least, and stirring the subsoil to an equal further depth, forming a reservoir for the storage of the rainfall to be held until evaporation brings it to the surface, or until the roots of the crops intercept and appropriate it as it rises to the surface.

The question of increasing rainfall gains an affirmative answer from practical cultivators, while the records of the rain gauge fail to make such response. Yet there is an increase, if not in actual rain, certainly in available moisture, because the water which formerly flowed away almost entirely, with almost as much facility as from the back of a duck, making no impression upon the induration of the surface, is almost wholly retained by the loose soil of cultivated lands. As irrigation becomes general, and continuous for years in its seasonal application, there is more moisture in the atmosphere, dews at night are frequent where formerly unknown, and the agricultural value of the atmosphere is enhanced. Practically there is a change in the climate, though the measured precipitation may be no greater than in the period of exclusive Indian occupation of the territory.

While irrigation is an actual necessity, and its results more beneficent in some respects than the abundant rainfall in the east, wherever it can be made available, extravagant assumptions in its behalf, made so frequently, should be avoided. The richest lands, with never-failing supply of moisture, have little value until population and general development of industry have had their influence in enhancing values. There is no such thing as a measure of value by degrees of fertility. There are some of the richest lands on the continent to be obtained, at from $1.25 to $5 per acre, while there are lands in Michigan formerly bogs, which are said to rent for $50 per acre, and others in New Jersey which command a much higher rental. Farmers will not pay extravagant prices for irrigable lands, with water rights, at present, though the changes of the future will advance their value.

The agriculture of the arid region has its peculiar problems for solution, which must be worked out upon the arid plains. After the best methods of cultivation have been determined, there is a wide field of experiment to obtain plants for cultivation best adapted to surrounding conditions.

Those plants will be selected which endure the ardent sunshine, the deficient moisture of this region, the tap rooted plants which are able to go down to seek the moisture, which as by an instinct of self-preservation seeks with instant urgency the underground channels and reservoirs, escaping dissolution by the process of evaporation under the fierce rays of the summer sun.

The capabilities of this great region for agricultural production are not yet appreciated. It will require time, skill, invention and perseverance to reach the ultimate and highest results. When reached, however, I am sure they will put to shame the expectation and faith of the present time.

The arid belt is to become a great manufacturing region. It has exhaustless mines of tin, copper, quicksilver, iron and other metals: gold and silver; soda and sands for glass; a limitless supply of coal for power and heating; and railways for easy distribution to the Pacific coast on one side and the great central valleys on the other. With irrigation directed and controlled by the government, and carefully guarded against the abuses of monopoly in land or water, there will be large areas in agriculture, yields heavy and sure from a soil fertile to excess, ample production for the supply of a dense population. Such is its certain future, but the development will be quicker, more beneficent, conserving better the rights of the working men whose share in the results should be made absolutely secure, if the irrigation system should be promptly constructed and surely controlled by the general government.

INUTILITY OF THE DESERT LAND ACT. By J. RICHARDS DODGE, Washington, D. C.

[ABSTRACT.]

THE land laws of the United States are based on the idea that farms shall be practically free to all citizens. They have been framed in such phraseology, and executed sometimes in a manner so antagonistic to their spirit, that honest settlers have been despoiled of their rights, and others have entered into the fruits of their initiatory labors. In some instances, persons have been called hundreds of miles, at great inconvenience, and subjected to ruinous delays, and to an aggregate expense, which in extreme cases amounts to two or three times the preëmption value of the land, to secure a perfect title to a common homestead claim. A tangle of technicalities has nullified the intended benefits of the law.

But it is not my purpose to indicate all the defects of the land laws, or the practical injustice so often witnessed in the harshness of their execution, but to call public attention to the inutility of the desert land act. It was framed in evident recognition of the fact that the arid lands, the soils useless for general farming, without irrigation, required an enactment essentially different from that which conferred a free homestead in the regions of adequate rainfall, or gave a privilege of purchase at the minimum price of $1.25 per acre. And yet it fails utterly of its intention as to nearly all the area of its operation.

A glimmering light seems to have been thrown upon the difficulty of irrigating each quarter section, each 160 acres, in the provisions of the law for the right to purchase a whole section, at $1.25 per acre, after the claimant had provided for its irrigation—its reclamation or habilitation as farm land. The purpose, which was the transformation of a desert to a garden, has utterly failed, except as to very limited margins of small streams which have considerable fall, areas so inconsiderable as scarcely to be worthy of consideration.

The streams are deeply embedded, so that irrigation of a single section could only be accomplished by employment of a steam engine, a pump of enormous power, and a system of canals—a plant almost sufficient to furnish water for a town, to be used in the cultivation of a single farm. It is impracticable, and therefore settlement has been delayed, and millions of acres that might be very productive are a waste, capable only of supporting a pair of oxen on a forty-acre tract, with the limitation of the imminent risk of their freezing to death in a hard winter.

The plan was doomed to be a failure. There are only two methods by which the reclamation can be accomplished: the general government can provide the water, keeping the irrigation works in perpetual repair, or capitalists, either singly or in association, must be permitted to acquire the lands, irrigate them, and sell small farms to cultivators, with perpetual water rights. Water rights may be rented by the company providing irrigation; or, better still, may be sold, the settlers themselves forming a coöperative company, charged with keeping the works in repair, and regulating the distribution of the water by the most equitable plan.

The grossest injustice has been done, in certain cases, to those who have taken up adjoining sections, in sufficient numbers to render possible and practicable a local work of reclamation, and expended hundreds of thousands of dollars in engineering works, and paid in full for the land, and then have been met by years of vexatious delay in obtaining a title, while interest has been eating up the investment, settlement has been barred, the state or territory injured in its production, revenues and internal improvements.

Thus, laws theoretically intended to promote settlement became a hindrance to development, an obstruction to cultivation, a fatal bar to progress. Yielding to clamor against monopoly, our lawgivers create a national monopoly of land, not for use, but to hold forever in a non-productive and valueless condition. Thus far the business of building irrigation works, on an extensive scale, has been far from profitable, entailing failures in many instances. Settlers will not pay high prices for irrigated lands, as the cropping possible in primitive settlements, without markets for the surplus, will not warrant it. In the dim and distant future, when population swarms and industry is highly developed, prices will advance; but present settlers cannot pay fifty dollars per acre, or twenty, and they are sometimes slow to offer ten for land with water rights.

It is believed that a better understanding of the problems of irrigation, and the necessity of providing the means of feeding the future industrial

population of the Rocky Mountain region, will overturn the present policy of repression, and open to settlement immense areas of land, fertile as any the sun shines upon, capable of supporting a dense population, waiting to utilize magnificent resources, which are now without value or possible use, except by the beneficent intervention of a government, which, while in theory offering free homes to all, in practice withholds from settlement a princely domain, dooming it without a change of policy to perpetual barrenness.

OUTLINE FOR A FISHERY CENSUS OF THE UNITED STATES. By CHAS. W. SMILEY, Washington, D. C.

[ABSTRACT.]

THE census of 1890 will be the eleventh general census of the United States. But so far as it relates to the fisheries, it will be only the second of any extent. The fishery census of 1880 covered a very wide range of topics, and from the material collected there have, thus far, been published seven quarto volumes; the matter being not only statistical, but descriptive and historical. The fishery census of 1890 will be strictly statistical and confined to leading features of the industry. The report will not exceed one volume in extent. All collateral inquiry with reference to the progress of fish-culture and the future fishery resources of the country should properly be left to the United States Fish Commission, which has ample means for investigating these subjects.

A fishery census may be divided into two parts, each requiring different treatment:

I. The fisheries proper, including the taking of fish, oysters, etc., and such expenditure of labor and materials upon them as is necessary for putting the product in condition to market or to use as material for manufacture.

II. The manufacture of fishery products, including the operations of smoking, salting, boxing, canning of fish and oysters, etc., and the making oil, guano, whalebone, leather, glue, isinglass, etc.

I. THE FISHERIES.

A. Their geographical extent.

The investigation should embrace an inquiry into the condition of the fisheries on: (1) The Atlantic Coast. (2) The coast of the Gulf of Mexico. (3) The Pacific Coast. (4) The Great Lakes. (5) The minor lakes and ponds, and (6) The rivers.

B. Objects of the fisheries.

The inquiry should embrace, as objects of the fisheries, the following, in addition to all the food fishes:

(*a*) Pinnipeds: seals, walruses, sea-lions, etc.
(*b*) Cetaceans: whales, blackfish, porpoises, etc.
(*c*) Reptiles: turtles, terrapins, frogs.
(*d*) Crustaceans: lobsters, crayfish, crabs, shrimps, etc.
(*e*) Mollusca: oysters, squid, clams, mussels, etc.
(*f*) Sponges.
(*g*) Marine plants: Irish moss, algæ, etc.
(*h*) Inorganic products of the sea: salt, sand, etc.

C. Topics to be considered.

1. *Fishing-grounds.* An enumeration of the grounds that are visited by professional fishermen, the seasons of the year in which fishing occurs upon each, the quantity of products obtained from each in 1890, are desired. This will include information as to what new grounds have been occupied since 1880. The number of men and vessels visiting each ground is desirable.

2. *Personnel.* It is necessary to ascertain with care the personnel of the fisheries. This includes owners, fitters, professional fishermen (who look to the fisheries for their entire income), semi-professional fishermen (who fish as a business only a part of the time), women, boys and girls assisting in the same. The ages of this class are important, as showing to what extent it could be drawn upon in time of war for naval recruits. The nationality and place of birth of these people are important. From the semi-professional fishermen, it is desirable to obtain statistics of the number of days or months per year during which they fish, or the proportion of their income derived from this industry. It is also desirable to have for each town, village, etc., along the entire coast line (Atlantic, Pacific, Gulf and Lake), the number of men engaged in each branch of the fisheries.

3. *Capital invested.* This will include for each minor division of the coast: (1) Apparatus (vessels, boats, fishing-gear, etc.); (2) equipment or outfit (salt, ice, bait); (3) shore property (outfitting stores, store-houses, refrigerators, ice-houses, wharves, land, vehicles, horses, cattle, steam-power, fish-cars, etc.); (4) working capital (cash, credit-capital, etc.).

4. *Vessels.* In detail, the following facts will be shown respecting the vessels: (1) name of vessel; (2) rig; (3) net tonnage; (4) date of construction; (5) place of building; (6) original cost and present value; (7) present value of apparatus and outfit; (8) kind and quantity of apparatus, including boats; (9) number of crews, nationality, and place of birth; (10) what fisheries engaged in during census year; (11) fishing season (what portion of the year employed in fishing. What other business engaged in during a part of the year).

5. *Boats.* The items required are: (1) number of sail-boats of less than five tons burden; (2) number of row-boats, canoes, etc.; (3) value; (4) number of men engaged in boat fishery in summer; (5) number of men engaged in boat fishery in winter; (6) number of men engaged in boat fishery all the year; (7) total number of boat fishermen, nationality and place of birth; (8) kind and quantity of apparatus; (9) value of apparatus; (10) fisheries engaged in, what other kinds of business employed in when not fishing. Proportion of time in each.

6. *Fixed Apparatus.*—Under this head will be shown, geographically, and by special fisheries, the quantities and values of various kinds of fixed apparatus, including pounds, floating traps, weirs, fykes, slides, wheels, seines, gill-nets, pots, baskets, etc. The location of these forms of apparatus will, if practicable, be indicated upon charts by the field-agents.

7. *Baits.*—The bait question being a very important one, it is proposed to show the kinds, quantities, and values of—(1) Bait caught by the fishermen at sea; (2) bait purchased from foreign countries; (3) bait exported from the United States; (4) bait used in the fisheries.

8. *Wages.*—This will include total remuneration for services during the year (1889), whether in the form of profits, "shares" or stated wages. So far as possible, the wages paid will be shown, not only for males and females, but by stated amounts per week.

9. *Rent, Taxes, Insurance, Commission, Interest, Freight and Transportation.*—The amount paid for each of these branches of expense should be stated in a form similar to that shown for other branches of industry, in order to enable the public to make comparisons.

10. *Products.*—For each minor division of the coast is required an enumeration of the amount and values (at prices realized by the fishermen) of each and all products of the fisheries. This includes not only fish sold fresh and salt, but for all purposes of manufacture, for bait, etc., all shell-fish, turtles, terrapins, fur-seals, sponges, etc.

II. MANUFACTURE.

Concerning the manufacture of fishery products, the following items will be obtained, which, in many respects, correspond with those required concerning other branches of the manufacturing industry:

(1) Name of company, corporation, or individual.

(2) Kinds of products manufactured.

(3) Capital invested (*a*) in land, (*b*) in buildings and fixtures, (*c*) in tools, implements, and means of transportation, (*d*) in machinery, and (*e*) in cash.

(4) The productive forces, including overseers and foremen, and divided into (*a*) males above sixteen years, (*b*) females above fifteen years, and (*c*) children and youths.

(5) Non-productive force, including officers (male and female), clerks, watchmen, engineers, drivers, etc.

(6) The wages or salaries paid to the productive forces.

(7) The wages or salaries paid to the non-productive forces.

(8) An enumeration of the various kinds and values of the materials consumed.

(9) The amount paid for rent, taxes, insurance, commissions, interest, freight, transportation, etc.

(10) The quantity and value of all products.

(11) The number of months in operation, on full time, on three-quarter time, on one-half time, on one-quarter time, and idle.

(12) The number of hours in an ordinary day of labor, from May to November, and from November to May.

(13) Wages paid per week, and the number of hands employed at each rate, both male and female.

(14) The number of hands employed, and wages paid on piece-work to males above sixteen and females above fifteen years, and to children and youths.

(15) The particulars concerning the power used in manufacturing, such as horse-power, steam-power, water-power, electric, gas, or other power.

The collection of data, which will be for the calendar year 1889, will be commenced in January, 1890, and will be secured by personal canvass, either of special agents drilled for the purpose, or by men selected in each locality for their large acquaintance with the subject. The compilation of the returns in Washington will be pushed forward with great vigor, in order that the results may be issued in Bulletins at the earliest practicable moment, and in order that the full report may be placed in the hands of the printer as early as January, 1892.

THE ABOLITION OF SLAVERY IN UPPER CANADA. By WILLIAM HOUSTON, M.A., Legislative Library, Toronto, Ont.

[ABSTRACT.]

IN 1793 the first Parliament of Upper Canada, in its second session, passed "An Act to prevent the further introduction of slaves and to limit the term of contracts for servitude within the province." The slaves for whose benefit this act was passed had been introduced under the authority of an act of the British Parliament, 30 George III, chap. 27, entitled "An Act for encouraging new settlers." It was passed in 1790, and its avowed object was to enable subjects of the United States, who desired to emigrate to Canada, or other British Provinces, to take with them their negro slaves as well as their household goods and farm implements, provided they obtained a license from the governor of the province they desired to enter. That some slaves were actually brought into Upper Canada under this law is certain, and the threatened evil of slavery attracted the attention of Lieutenant Governor Simcoe and the first parliament of Upper Canada in 1793. The act passed by that Parliament for its

abolition contained four main provisions. The first prohibited absolutely the further introduction of slaves as such, and made them free on arrival in the province. The second was to the effect that all who were then legally in a state of slavery should remain so until set free by their own proprietors. The third limited the term of servitude to twenty-five years in the case of children born of slave parents after the passage of the act, and made the children born of such infantile slaves free from birth. The fourth required each proprietor, on the enfranchisement of his slave, to give security to his parish or township that the freedman would not become a burden upon it. The immediate effect of this law seems to have been a reduction in the value of negro slaves; and its not very remote effect the entire abolition of the institution. There is no record of any slaves in Toronto later than 1811. It is probable that Lieutenant Governor Simcoe was the instigator of the antislavery legislation, as abolitionism was then active in England from which country he had recently come. This probability is increased by the fact that in his speech from the throne at the close of the session he expressed in strong terms personal satisfaction that by the act he was freed from the duty of giving licenses for the importation of slaves.

ECONOMIC IMPROVEMENT OF TRADE CHANNELS. By Comd. HENRY C. TAYLOR, U. S. N., New York, N. Y.

AGRICULTURAL EXPERIMENT STATIONS. By Prof. W. O. ATWATER, Middletown, Conn.

ECONOMIC ASPECTS OF EDUCATION. By Prof. JOHN EATON, President of Marietta College, Marietta, Ohio.

THE SOCIOLOGICAL POSITION OF FREE TRADE. By Prof. LESTER F. WARD, Washington, D. C.

SOCIAL ECONOMICS. By Mrs. LAURA OSBORNE TALBOT, Washington, D. C.

MANUAL TRAINING. By Prof. C. M. WOODWARD, Director of Manual Training School of Washington University, St. Louis, Mo.

CONCLUDING REMARKS UPON THE ECONOMIC AND SOCIOLOGIC RELATIONS OF CANADA AND THE UNITED STATES. By Col. CHARLES S. HILL, Washington, D. C.

EXECUTIVE PROCEEDINGS.

REPORT OF THE GENERAL SECRETARY.

GENERAL SESSIONS OF THE THIRTY-EIGHTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE HELD IN TORONTO, ONTARIO, AUGUST 28 to SEPTEMBER 8, 1889.

ON WEDNESDAY, AUGUST 28, the first GENERAL SESSION of the Association was held in Convocation Hall in the University Building of the University of Toronto. The PERMANENT SECRETARY called the meeting to order at 10 A. M. and requested the Senior Past President, JAMES D. DANA of New Haven, to take the chair in the absence of President J. W. POWELL of Washington. President DANA then formally opened the proceedings, and resigned the chair to the President-elect, T. C. MENDENHALL of Washington. President MENDENHALL in assuming the duties of his office addressed the Association as follows:—

There has been a long established rule, which, in fact, forms a part of the constitution of this Association, restricting the privileges of the presiding officer. Especially is it a well-known principle of the Association that the talking power of the presiding officer shall be limited. Should it be his good fortune to so discharge his duties as to escape impeachment he will look forward to the next year when a special session will be set aside during which he may express his views on anything he may desire.

To indulge in any lengthy address will be to violate the rules of the Association. You will however, I am sure, indulge me while I embrace this first and perhaps only opportunity of thanking you for the great honor you have conferred upon me by electing me to preside over the American Association whose past has been so rich in performance and whose future is so full of promise. No words of mine can express the appreciation of the honor so conferred.

In conclusion I can only say that it shall be my endeavor to discharge the duties intrusted me in a manner satisfactory to the Association.

Prof. CHARLES CARPMAEL, President of the Local Committee, addressed the Association as follows:—

Mr. President, Gentlemen and Ladies of the American Association for the Advancement of Science:—You have been assembled this morning in order that you may have addressed to you a few words of welcome on this your third visit to Canada and first to Toronto, from those who invited you here. In August of last year, during your meeting in Cleveland, I, as president of the Canadian Institute, had the pleasure of forwarding to you an invitation to hold your next meeting in Toronto. This invitation was

concurred in by the Minister of Education, the Vice-Chancellor of the University of Toronto, on behalf of the Senate of the University, and by the Mayor on behalf of the City of Toronto. You will be addressed in turn this morning by persons representing each of these bodies. Before calling upon others, it is my privilege, as President of the Local Committee, myself to address to you a few words of welcome. In the name, then, of the Local Committee, I bid you welcome, but I hope that the arrangements which have been made for your convenience and comfort during your stay here will speak a more forcible welcome than any words of mine could do. The committee have done their utmost to make those arrangements as complete as possible, and if—for even with the best intentions we are all liable at times to fail in our endeavors—if in anything you should find that we have not done all that you expected of us, I trust that you will put it down to our inexperience and not to any lack of zeal or earnest desire on our part to do all that we could. Your programme will show what we have been able to do, so on this subject I need not waste your time. All I need say is that the different railway and steamboat companies have offered excursions at liberal rates to almost any part of Canada; we are to have two free excursions, the city will give you more than one entertainment, and some of our citizens also hope to see you at their homes. Now, as I am president of the Canadian Institute, one of our oldest scientific bodies, it dating its birth forty years ago, allow me to say a few words on behalf of our scientific men. We, as men of science, welcome most heartily the American Association for the Advancement of Science into our midst. We welcome you all, collectively and individually, not only those veterans in science who have already done much, whose names are known throughout the scientific world and are even not unknown to those not particularly interested in science, but also those recent recruits, if any such there be among you, whose names are not yet widely known, bnt who, like those veterans, are striving to add their quota to the general stock of knowledge, and who, we may hope, will one day equal, nay—as knowledge advances rapidly in this age—may one day far surpass the veterans of to-day. We feel that you are all fellow-workers with us in a great cause. We welcome you all, whether citizens of the United States or Canadians, for the American Association for the Advancement of Science is truly American, and is not confined to one section of this great continent. Science, as Lord Lytton says in one of his novels, "cares not a jot for men and nations," and so, although as individuals we may differ on questions political, although as citizens of different countries we may differ as to our respective rights of fishing in certain waters, and, too, on other matters, yet as men of science we are fellow-workers, and our sole rivalry shall be the friendly strife of each trying to outdo others in probing the hidden mysteries of nature.

On behalf of the Government of Ontario, the Minister of Education, the Hon. G. W. Ross, welcomed the Association in the following words:—

It is my duty, on behalf of the Government of the Province of Ontario

to welcome the Association on the occasion of its thirty-eighth annual session and personally I am very glad of the privilege of doing so, because this annual session promises to be a very great and successful one.

We in the Dominion of Canada are at all times glad to receive among us the representatives of every organization, whether for the promotion of science or philanthropy, who choose our land as their place of meeting, and we are particularly glad on the present occasion to welcome the representatives of the most advanced scientific thought of Canada and the United States, in order that we may profit by the occasion by coming in contact with your members.

Perhaps in no part of the continent where the Association has met is there a greater amount of interest taken in educational matters than in Ontario. Here, when laying the foundations of our school system, we have carefully cast around for a model adapted to our peculiar environments, and we have ultimately come to the conclusion that some parts of the New England system were better adapted to them than any other, and so we have largely copied it in our elementary schools. I think this a fitting occasion to recognize our indebtedness to the representatives of those states who are on the platform in having admitted the cardinal principles of the New England system of elementary and secondary education into the Province of Ontario. In addition to this, we have in Ontario watched with interest the progress of university education and the scientific energy of the United States. We have noticed that progress with some pride, and I shall also admit with some little solicitude; we were proud of the success, but solicitous because the universities of the New England states often enticed away some of our most brilliant men, and having so enticed them, kept them. But, in Ontario, we are always proud of our neighbor's prosperity, although sometimes, too, a little jealous because of the slender endowments which we were able to get for some of our own universities, and we could not but look with some jealousy at Cornell, Harvard and Yale. Not but we were proud of the United States all the time, but we looked on with some hesitation about the consequences to the future of our own education in this province. But I am happy to say that the dark cloud has rolled away, and to assure the American visitors of the Association for the Advancement of Science that education in Ontario is now in a prosperous condition. I am proud to say that within its limits the educational system of Ontario has achieved a great deal. Again I welcome the members of the Association to Canadian soil. Here we are proud of the trophies and achievements which have resulted from the great system of scientific research and education developed in the United States and in Her Majesty's Dominions. Here we are touched with the glow of enthusiasm in behalf of science which the Association has spread over the continent, and here in Her Majesty's Dominion we hope for still further progress. I can assure the associates present that in this province they will find themselves in congenial atmosphere, in the company of men of firmness, perseverance, and I would also say of humility, which is an important quality in scientific research.

We are always glad in Canada to meet our American fellow-citizens. There was a time in Canada when a visit was paid us by a body of United States citizens inquiring into our scientific condition. I don't think it was more than seventy-five years ago when this company of scientists visited us in a ship, and struck their sails in Toronto harbor. The exhibition of fire-works which they gave us was very disastrous for Toronto, and the only thing which we could do was to give them a similar exhibition in return, so we went over and played upon the cities of Buffalo and Detroit, and made ourselves generally disagreeable all along the line. But I am happy, Mr. President, to say that these days have gone by, and I think that if any invocation were necessary we would on both sides beseech the God of our forefathers to avert such a calamity in the future. The energy of Americans has been demonstrated in the development of their great country, and we are glad of it, because we have a larger geographical area of our own to develop. We are glad to testify to the stability of the American constitution, notwithstanding the opinion of Macaulay to the contrary given fifty years ago. It is then with unbounded joy and satisfaction that we welcome to our shores representatives of the country which has produced statesmen like Washington and Lincoln, poets like Longfellow and Whittier, and orators like Webster, Clay and Sumner. We confer upon you the freedom of the Province of Ontario, a province which is larger than all your New England states, which is enterprising, progressive and partially civilized at least. We, without let or hindrance, confer upon you freedom to fish in our lakes and inland waters, notwithstanding the treaty of 1818, or the three-mile limit—on one condition, that when you return to your home you do not excel in those extraordinary reports of piscatorial adventures which we sometimes hear, even from the professors in our colleges. We give you freedom to botanize in our woods and fields, on condition that you regard the emblematic maple leaf and British oak. And we give you freedom to geologize on our mountains, on condition that you do not make comparisons between your Sierras and Alleghanies and our Rockies, and we give you freedom to mineralize in our mines, on condition that you do not get up a corner and embarrass our Canadian capitalists. And we hope that when you leave our shores you will have found that your stay among us was as merry as a marriage bell, that the time which you passed under the sheltering folds of the British flag was as happily and profitably spent as any corresponding period spent under the stars and stripes of free America.

Mr. William Mulock, M.P., Vice-Chancellor of the University read the following address of welcome, and presented it to the President of the Association:

Mr. President and Members of the American Association for the Advancement of Science:—

The Chancellor, Vice-Chancellor and Members of the Senate of the University of Toronto tender to you their cordial greetings on this your first meeting in the capital of Ontario and welcome you to the halls of the Pro-

vincial University, where it will be their earnest endeavor to furnish every facility in order to the successful carrying on of the work of the Association. They welcome the members of your Association as representatives of pure science in its grandest aspects and as searchers into recondite truths the mastery of which has already contributed in so many ways to the promotion of the highest practical interests of civilization. They welcome you no less heartily to this seat of learning in the full assurance that the presence of so many of those whose names are associated with the most recent discoveries in science and with their practical application to the arts, the commerce and the social life of nations, cannot fail to give a fresh impetus to studies which here engage the attention of a younger generation, and prepare fresh aspirants for carrying on the same work to new and higher results. With no less cordial greeting they welcome you to this meeting on British soil in a province of the Dominion of Canada, an integral part of that great empire with which the history of your own country is so closely identified, in the confident hope that those who are one in a common lineage with Napier, Bacon, Newton and Locke may continue to be bound together alike by glorious memories, by grand interests of the present, and by lofty aspirations. It is the earnest desire of those who now extend to you their most cordial welcomes, that important additions to scientific truth may reward the labors of all who share in the deliberations of this Association.

His Honor the MAYOR OF TORONTO, Mr. CLARKE, said:—

Mr. President, Ladies and Gentlemen:—The pleasing duty has devolved upon me this morning of extending to you in the name and on behalf of my fellow-citizens a very hearty welcome to Toronto. We recognize not only a very graceful compliment in the visit of so many scientific men to our city, but also feel very highly honored from the fact that this is the first occasion upon which the meeting has been held in this Province. We earnestly hope your stay in our midst will be both pleasant and profitable, and that during your sojourn you may feel, if not at home, at least surrounded by warm friends. We recognize also the very great importance of the work in which you are engaged, the distinguished services rendered, and the advances made in science by your Association. I trust that your meeting on Canadian soil may be even more successful than its predecessors in promoting the objects of the Association and intercourse between those who are pursuing science on both sides of the border, and that it will still widen and broaden your sphere of usefulness. Recognizing, therefore, the importance of the work in which you are engaged, and the value of your time, it would not be proper for me after the admirable addresses delivered by the Minister of Education, the President of the Canadian Institute and the Vice-Chancellor of the University, to say more, and I will merely conclude by again extending to you the heartiest greetings and the best wishes of the people of Toronto.

President MENDENHALL in reply to the various addresses of welcome said: I find it difficult to address at one and the same time the gentlemen

who have spoken addresses of welcome from both sides of the platform. But I take it as a happy omen for our session that we have been welcomed from both sides, and I take a personal pleasure in responding this morning on the part of the Association for the Advancement of Science to this very generous welcome. I may remark that I only regret that the duty of making this response has not fallen on some one more competent than I am to express the feelings of the members of the Association. My consolation and explanation are that the members of the Association are accustomed, and are able and willing to speak for themselves. I need only say that I can assure you I reflect their sentiments, when I thank you most cordially for your hearty welcome. It is not generally known that the American Association for the Advancement of Science has been carrying on for several years a sort of flirtation with the city of Toronto, and on many occasions, your able and intelligent representatives portrayed to us the advantages of holding a meeting here and though it was our desire to do so we always said no, meaning yes, of course, but not wishing to appear too willing. But about a year ago the day was fixed and here we are greatly to our own satisfaction and I trust to yours also.

Turning to Professor Carpmael, the president thanked him for the terms of his address and also thanked Mr. Ross, Mayor Clarke and Mr. Mulock for their references to the international character of the American Association. The Association should always be referred to in its continental sense and not in any sectional sense of the word. You all know that science is not spoken of as a respecter of parallels of latitude or meridians of longitude or other obstructions of a disagreeable character. Those who fish in its waters fish with absolute freedom and the rewards not the punishments are measured in proportion to the size of the catch. The international character of the Association can best be judged by studying its membership. It reveals the fact that at least a fair proportion, in fact a large proportion, of the members are citizens of Canada, and many of the Canadian members have at various times been selected for the various positions of honor, including the highest. The meetings to be held during the week I trust will not be devoid of interest to the citizens of Toronto, and I take pleasure in cordially inviting you to attend the meetings of the Association, not only in general sessions, but also meetings held elsewhere as indicated in the programme. The sectional meetings are free, and the matters coming up at them allow a wide variety of choice. Thus, if the visitor finds the study of biology too exciting he can have recourse to the more soothing subject of anthropology where he will hear nothing but the truth entire and unvarnished. Thus the members hope in some way to be able to repay the citizens of Toronto for the generous welcome which they have extended, which has no three-mile limit.

The GENERAL SECRETARY announced that the COUNCIL recommend, that morning sessions begin at 10 o'clock, that a recess be taken from 12.30 to 2 P.M., and that a General Session be held every morning except on Saturday; those on Thursday, Friday and Monday mornings to be limited to fifteen minutes.

These recommendations were adopted by the Association. The Association elected the following named gentlemen, nominated by the COUNCIL to fill vacancies: — H. CARRINGTON BOLTON of New York, *Secretary of the Council*, in the absence of Frank Baker of Washington; JAMES DENTON of Hoboken, N. J., *Vice-President of Section D* in the absence of Arthur Beardsley of Swarthmore, Pa.

It was announced that the COUNCIL had on behalf of the Association accepted the several kind and generous invitations to receptions tendered by the City of Toronto and by the Ladies, as named in the Daily Programme.

Attention was called to the two public lectures arranged for by the COUNCIL to be given in the Pavilion, complimentary to the citizens of Toronto,—one by Mr. G. K. GILBERT of the United States Geological Survey, on the Geological History of Niagara River; the other by Dr. H. CARRINGTON BOLTON of New York, entitled Four Weeks in the Desert of Sinai.

The PERMANENT SECRETARY made several announcements and presented the Financial Report showing that the Association was free from debt,—a more favorable condition than it had found itself in for many years.

After several announcements by the SECRETARY OF THE LOCAL COMMITTEE, Professor LOUDON, the General Session was adjourned for the organization of the Sections.

In the evening the usual GENERAL SESSION was held for the purpose of listening to the address of the RETIRING PRESIDENT, Major J. W. POWELL of Washington. President MENDENHALL, in opening the session, said:— I regret extremely to inform you that Major Powell the Retiring President, to whom you have come to listen cannot be present; particularly as you have been led to expect him from the fact that his photograph has appeared in the public newspapers. It is to be hoped, however, that the Major will outlive any false impressions that may have arisen from it.

Major Powell's absence is caused by the fact that the U. S. Government has lately undertaken to reclaim some of the arid lands of the west and his services as Director of the U. S. Geological Survey were required to superintend the plans for the proposed work of irrigation.

At the last moment Major Powell has written a letter of regret from which I will read a few lines. He says, "Permit me to express through you my sincere wish that the Toronto meeting may be eminently successful and that the proceedings may serve to advance scientific investigation and band together the scholars of the Dominion and the United States in a common effort to advance science." Not having Major Powell with us, we have the next best thing,—his paper on the Evolution of Music—which has been prepared for this occasion and which will now be read by his distinguished colleague in the U. S. Geological Survey, Mr. GILBERT, whom I have the honor of presenting.

At the close of the reading of Major Powell's address (see p. 1 of this volume), President MENDENHALL expressed the appreciation of the Association for the reception tendered this evening, saying this appreciative audience was a tribute of respect to the living representatives of science,

and the appropriate decorations were a tribute to the long line of scientists who had passed away. He could assure the citizens of Toronto that their reception was highly appreciated and had rarely been equalled in the history of the Association.

Mayor CLARKE expressed pleasure at seeing the large turnout of citizens, and called upon Alderman DODDS to make some announcements.

Alderman DODDS announced that the City Council hoped the following evening to have the attendance of the ladies and gentlemen in the Pavilion, when a promenade concert would be given. They came from the grandest republic of the world's history, and he could assure them that Canadians were as unswerving in their loyalty to the old land as they as citizens of the United States were to their own land. He hoped that their visit to Toronto would be a pleasant one.

THURSDAY, AUGUST 29, 10 A. M. President MENDENHALL in the chair. By order of the COUNCIL the following letter from the Woman's Christian Temperance Union was read.

Toronto, August 28, 1889.

HONORED GENTLEMEN:—The members of the Woman's Christian Temperance Union of Toronto District send greeting.

That your coming together may be productive of great good is the prayer of five hundred women of Toronto.

Signed in behalf of Toronto District W. C. T. U.

MRS. J. TROUTMAN, *Cor. Sec.*
MRS. J. FORSTER, *Rec. Sec.*
MRS. R. MCDONELL, *President.*

14 York Chambers, Toronto.

The LOCAL SECRETARY made the following announcements:—

The Amateur Photographic Association had invited members to visit their rooms in the Medical Council building, corner of Richmond and Bay streets, any time during their stay in the city; the Granite Club, Church street, also offered the privileges of their premises, as also did the Royal Canadian Yacht Club. Any member, apart from the geological section, who wished a copy of the geological map of Ontario, might have one at the Local Secretary's office. The General Session then adjourned, and the reading of papers began in the various sections.

At the GENERAL SESSION on FRIDAY, AUGUST 30, presided over by President MENDENHALL, Professor SEAMAN of Washington presented a resolution relating to uniformity in publishing scientific papers, which was referred to the COUNCIL.

MONDAY, SEPTEMBER 2, 10 A. M. GENERAL SESSION IN CONVOCATION HALL. President MENDENHALL having called the meeting to order, expressed the pleasure with which the Association greeted the many Past

Presidents in attendance. At no recent meeting had they been permitted to see in their midst so many whom they had honored and continued to honor. Of the seven present, Professors JAMES D. DANA, JAMES HALL and J. S. NEWBERRY, were the three senior presidents of the Association.

The communication from the COUNCIL in reference to Reports of Committees was acted upon as follows:

1. Committee on Indexing Chemical Literature presented a report and was continued.

2. The Committee on International Congress of Geologists reported progress and was continued.

3. The Committee on Anatomical Nomenclature with Special Reference to the Brain reported progress and was continued.

4. The Committee on Physics Teaching rendered its final report at the Cleveland meeting asking to be discharged at that time; no record of its discharge then appearing, the Committee was now discontinued.

5. Committee to apply to Congress for a Reduction of the Tariff on Scientific Books and Apparatus, continued.

6. Committee to memorialize Congress to take steps for the preservation of Archæologic Monuments on the Public Lands, continued.

7. Committee on Universal Language, continued.

8. Committee on Chemistry Teaching reported and was discharged.

9. Committee on Water Analysis reported and was continued.

10. Committee of Conference on organization of a National Chemical Society reported and was discharged.

11. The Honorary Special Agent of Transportation for the Association to act with the Local Committee, Mr. Dudley, reported through the Permanent Secretary and was reappointed. His report was ordered to be read at the meeting on Tuesday morning.

The LOCAL SECRETARY announced that the members of the National Club had much pleasure in placing their rooms at the disposal of the members of the Association during their stay in Toronto.

TUESDAY, SEPTEMBER 3, 10 A. M. GENERAL SESSION in CONVOCATION HALL. President MENDENHALL in the chair.

The GENERAL SECRETARY announced from the NOMINATING COMMITTEE the following list of officers nominated for the next meeting of the Association, and in accordance with the unanimous vote of the Association, cast a single ballot for the entire list, who were thereupon declared elected as follows:

PRESIDENT.

GEORGE L. GOODALE of Cambridge, Mass.

VICE PRESIDENTS.

A. **Mathematics and Astronomy**—S. C. CHANDLER of Cambridge, Mass.

B. **Physics**—CLEVELAND ABBE of Washington.

C. **Chemistry**—R. B. WARDER of Washington.

D. **Mechanical Science and Engineering**—JAMES E. DENTON of Hoboken, N. J.

E. **Geology and Geography**—JOHN C. BRANNER of Little Rock, Ark.

F. **Biology**—C. S. MINOT of Boston, Mass.

H. **Anthropology**—FRANK BAKER of Washington.

I. **Economic Science and Statistics**—J. RICHARDS DODGE of Washington.

PERMANENT SECRETARY.

F. W. PUTNAM of Cambridge (office Salem, Mass.).

GENERAL SECRETARY.

H. CARRINGTON BOLTON of New York.

SECRETARY OF THE COUNCIL.

JAMES LOUDON of Toronto.

SECRETARIES OF THE SECTIONS.

A. **Mathematics and Astronomy**—WOOSTER W. BEMAN, of Ann Arbor, Mich.

B. **Physics**—W. LECONTE STEVENS of Brooklyn, N. Y.

C. **Chemistry**—W. A. NOYES of Terre Haute, Ind.

D. **Mechanical Science and Engineering**—M. E. COOLEY of Ann Arbor, Mich.

E. **Geology and Geography**—SAMUEL CALVIN of Iowa City, Iowa.

F. **Biology**—JOHN M. COULTER of Crawfordsville, Ind.

H. **Anthropology**—JOSEPH JASTROW of Madison, Wis.

I. **Economic Science and Statistics**—S. DANA HORTON of Pomeroy, Ohio.

TREASURER.

WILLIAM LILLY of Mauch Chunk, Pa.

AUDITORS.

HENRY WHEATLAND of Salem, Mass. AND THOMAS MEEHAN, Phila., Pa.

The further report from the NOMINATING COMMITTEE recommending that from the cordial invitations to meet in Washington, D. C., Nashville, Tenn., Pittsburgh, Pa., Louisville, Ky., Rochester, N. Y., Concord, N. H., Easton, Pa. (for 1891), and Indianapolis, Ind., the one from INDIANAPOLIS be accepted, and the date be fixed for the third Wednesday in August [Aug. 20] for the first General Session, was concurred in.

The election by the COUNCIL of seventy-two Fellows was announced as follows:—

Arey, Albert L., Rochester Free Academy, Rochester, N. Y. (35). **B C**
Ashley, Prof. W. J., Toronto, Ont. (38). **I**
Avery, Elroy M., Cleveland, O. (37). **B**
Bailey, Prof. E. H. S., University of Kansas, Lawrence, Kansas (25). **B**
Battle, Herbert B., Director Agricultural Experimental Station, Raleigh, N. C. (33). **C**
Baur, Dr. George, New Haven, Conn. (36). **F**
Bell, Robert, M.D., LL.D., Assistant Director, Geol. Survey of Canada. Ottawa (38). **E**
Bennett, Wm. Z., Prof. Chemistry, University of Wooster, O. (33). **C**
Blake, Francis C., Mansfield Valley, Pa. (29). **C**
Blue, Archibald, Assistant Minister of Agriculture, Toronto, Ontario (35). **I**
Bryce, George, LL.D., Manitoba College, Winnipeg, Manitoba (38).
Burgess, Dr. Thomas J. W., Hamilton, Ont. (38).
Calvin, Prof. Samuel, State University of Iowa, Iowa City, Iowa (37). **B E**
Carpenter, Louis G., Fort Collins, Colorado (32). **A B**
Chute, Horatio N., Instructor of Physics, High School, Ann Arbor, Mich. (34). **A B**
Colburn, E. M., Peoria, Ill. (38). **H**
Cook, Chas. Sumner, Prof. of Physics, Northwestern University, Evanstown, Ill. (36). **B**
Crawford, Morris B., Prof. of Physics, Wesleyan University, Middletown, Conn. (30). **B**
Dawson, Dr. George M., Assistant Director Geological Survey, Ottawa (38). **E**
Ellis, Dr. W. H., Prof. of Chemistry, School of Practical Science, Toronto, Ont. (38). **C**
Ewing, Thomas, jr., Columbia College, New York, N. Y. (36). **B**
Eyerman, John, Instructor in Mineralogy, Lafayette College, Easton, Pa. (33). **C**
Floyd, Richard S., 120 Sutter Street, San Francisco, Cal. (34). **A**
Gaffield, Thos., Boston, Mass. (29). **C**
Galbraith, John, Prof. of Engineering, University of Toronto, Toronto, Ont. (38). **B**
Goff, Prof. E. S., Madison, Wis. (35). **F**
Gray, Thos., B. Sc., Prof. of Dynamic Engineering at Rose Polytechnic Inst., Terre Haute, Ind. (38). **B D**

Haines, Reuben, Germantown, Philadelphia, Pa. (27). C
Harrington, H. H., Prof. of Chemistry at Agricultural College, College Station, Texas (35). C
Hay, Prof. O. P., Butler University, Irvington, Ind. (37). F
Hill, Prof. Robert T., University of Texas, Austin, Texas (36). E
Horton, S. Dana, Washington, D. C. (37). I
Howard, L. O., Asst. Entomologist, Dept. of Agriculture, Washington, D. C. (37). F
Jacobus, Prof. David S., Stevens' Institute, Hoboken, N. J. (37). D A
Klotz, Otto Julius, Field Astronomer, Dominion Government, Preston, Ont. (38). A
Ladd, E. F., Agricultural Experimental Station, Geneva, N. Y. (36). C
Lloyd, Mrs. Rachel, Ph.D., Prof. of Analytical Chemistry, Lincoln, Neb. (34). C
Loeb, Morris, Ph.D., New York, N. Y. (36). C
Loudon, Prof. J., Prof. of Physics, University of Toronto, Toronto, Ont. (38). B
Macallum, Archibald B., Lecturer on Physiology, University of Toronto, Toronto, Ont. (38). F
McCreath, A. S., Harrisburg, Pa. (33). C
Meek, Seth E., Coe College, Cedar Rapids, Iowa (35). F
Morgan, F. H., Ithaca, N. Y. (35). C
Moser, Jeff. F., Lieut. U.S.N. Coast Survey, Washington, D. C. (28). E
Myers, John A., Prof. of Chemistry, Agricultural College, Oktibbeha Co., Miss. (30). C
Novy, F. G., University of Michigan (36). C
Osmond, I. Thornton, Prof. of Physics, State College, Centre Co., Pa. (33). B
Palmer, Prof. Chace, Ph.D., Prof. of Chemistry, Wabash College, Ind. (38). C
Peters, Edward T., Agricultural Dept., Washington, D. C. (33). I
Phillips, Francis C., Western University, Allegheny, Pa. (36). C
Preston, E. D., U. S. C. and G. Survey, Washington, D. C. (37). A E
Reid, Henry F., Prof. of Physics, Case School of Applied Science, Cleveland, O. (36). B
Robinson, Francis C., Prof. of Chemistry, Bowdoin College, Brunswick, Me. (29). C
Schweinitz, E. A. von, Ph.D., Salem, N. C. (36). C
Selwyn, Dr. Alfred R. C., Director of Geol. Survey of Canada, Ottawa, Can. (38). E
Shimer, Porter W., Easton, Pa. (38). C
Shutt, Frank T., M.A., Dominion Experimental Farms, Ottawa, Ont. (38). C
Smith, Edgar F., Ph.D., Prof. of Chemistry, University of Pa., Philadelphia (33). C
Snow, Benj. W., Cornell University, Ithaca, N. Y. (35). B
Spencer, G. L., Department of Agriculture, Washington, D. C. (36). C

Stoddard, John T., Prof. of Chemistry, Smith College, Northampton, Mass. (35). C

Taylor, H. C., Commander U.S.N., Poughkeepsie, N. Y. (30). I

Traphagen, F. W., Ph.D., Prof. of Chemistry, College of Montana, Deer Lodge, Mon. (35). C

Trimble, Dr. Henry, Prof. of Chemistry, School of Pharmacy, Philadelphia, Pa. (34). C

Vasey, George, M.D., Dept. of Agriculture, Washington, D. C. (32). F

Waldo, C. A., Prof. of Mathematics, Rose Polytechnic Institute, Terre Haute, Ind. (37). A

Ward, William E., Port Chester, N. Y. (36). D

Willis, Bailey, U. S. Geol. Survey, Washington, D.C. (36). E

Wilson, William Powell, University of Pa., Philadelphia, Pa. (38). F

Winslow, Arthur, State Geological Survey, Little Rock, Ark. (37). E

Wright, Prof. R. Ramsay, Toronto, Ont. (38). F

Wright, Thomas W., Union College, Schenectady, N. Y. (36). B

Youmans, Wm. Jay, 1 Bond St., New York, N. Y. (28). C F H

The GENERAL SECRETARY then read the following resolutions approved by the COUNCIL and they were unanimously adopted.

Resolution in reference to the Maintenance of Timberlands.

Resolved, that it is the sense of Section I that the Association through its Council should appoint a committee to memorialize Congress in behalf of the establishment of a proper administration of the remaining timber lands in the hands of the general government for the purpose of insuring the perpetuity of the forest cover on the western mountain ranges, preserving thereby the dependent favorable hydrologic conditions.

Resolution in reference to the Development of the Natural Resources of the Country.

Resolved, that the several great economics of our country demand careful and just consideration and encouragement by legislative enactments which will aid the scientific development of the natural resources of our country proportionate to the rapidly advancing conditions of our people in industry and science.

Resolved, further, that a committee of five be and is hereby appointed to present these resolutions, and to urge the importance thereof to the President and Congress of the United States, and the Premier and Parliament of Canada, and that such committee be instructed to prepare in proper form any data necessary and to use every honorable and earnest means to accomplish the purpose herein set forth, and that the president of this Association be hereby appointed the chairman of such committee, together with four others whom he shall appoint.

In accordance with above resolutions the following committee was appointed:

T. C. MENDENHALL, Washington, D. C., *Chairman;* E. W. HILGARD, Berkeley, Cal.; C. E. BESSEY, Lincoln, Neb.; B. E. FERNOW, Washington, D. C.; WILLIAM SAUNDERS, Ottawa, Canada.

Resolution requesting the Congress of the Three Americas to consider the Remeasurement of the Peruvian Arc.

Whereas, the history of geodesy includes no more important page than that relating to the measurement in 1749 of the so-called Peruvian arc, which work was conducted by the French government with the coöperation of Spanish officers, and in magnitude of plan and difficulty of a most serious character it was in its time unexcelled; *Whereas* recent improvements in all the processes incidental to such an undertaking have been so very great, rendering possible a vastly more accurate execution of the work; *Whereas*, it is and has been for several years a matter of deep regret that the one great contribution which the American continent has made to the solution of the problem of the figure of the earth should fall so short of what it should and might be; therefore, be it *Resolved*, by the American Association for the Advancement of Science, that the Congress of the Three Americas about to assemble in Washington is earnestly requested to consider the desirability of undertaking the measurement of this Peruvian arc, to be accomplished by a union of the republics represented. This result is not likely to be reached except through international effort, and this recommendation by the congress would be a fitting and proper act of this first conference of representatives of the New World.

Resolved, that a draft of a memorial relating to a Universal Day be referred for report at the next meeting to the following committee:—

R. S. Woodward of Washington; William A. Rogers of Waterville; William H. Dall of Washington; Charles Carpmael of Toronto.

Resolved, that a committee of Section C on Spelling and Pronouncing Chemical Terms be made a special committee of the Association as follows:—

Thomas H. Norton of Cincinnati; H. Carrington Bolton of New York; James Lewis Howe of Louisville; Edward Hart of Easton.

The Permanent Secretary read a letter covering the report of Mr. Dudley, Special Agent on Transportation, announcing that for the next meeting of the Association more perfect preparations to secure reduced rates would be made. The Permanent Secretary also acknowledged the important aid received from Mr. Callaway of Toronto in suggesting plans for the better accomplishment of the end sought.

The General Secretary announced that the following grants from the income of the Research Fund had been made by the Council:—

One hundred and fifty dollars to Prof. E. W. Morley of Cleveland, O., for Measurements on the Velocity of Light in a Strong Magnetic Field.

Fifty dollars to Prof. W. O. Atwater for experiments to be made under his direction on the Heat of Combustion of certain Vegetable and Animal Compounds.

Tuesday Evening, September 8. The concluding General Session of the Association was held in Association Hall. President Mendenhall called the Association to order at 8.30 P.M. The Permanent Secretary,

Professor PUTNAM, in a few words reviewed the work done during the meeting, and presented the usual statistical report of the meeting. He then read a letter from a lady member of the Association, accompanied by a check for $500.00 which she had generously placed at the disposal of the Council, for the advancement of original research, with the suggestion that a hundred dollars should be added to each of the grants made in the morning. [At the meeting of the Council after the adjournment of the General Sessions, the thanks of the Council were voted to the generous donor and the Permanent Secretary was instructed to carry out the expressed wishes of the donor.]

Prof. F. W. CLARKE from the Committee on Resolutions offered the following:—

Resolved, that we the members of the Association for the Advancement of Science, hereby express our heartfelt thanks to the Citizens of Toronto for the great interest they have shown in the meetings of the Association, their untiring efforts to make the gathering successful, their courtesy to all, and their lavish hospitality.

In particular our thanks are due to the Local Committee, whose admirable arrangements have made this, the third Canadian meeting of the Association, one of the most brilliant of its history. To them we owe the many details of personal comfort upon which the success of the meeting so largely depended. Never has this work been better done, and seldom so well. To them also belongs the credit of the delightful excursions to Niagara and to Muskoka lakes, which have been memorable features of this year's assemblage.

To the authorities of the University of Toronto and the School of Practical Science we are indebted for our place of meeting, and for a completeness in the facilities offered which has rarely been equalled in other cities.

We gratefully acknowledge the attentions shown the Association by the Mayor and City Council of Toronto, and especially their kindness in providing two of the pleasantest entertainments of the meeting—the promenade concert at the Pavilion and the garden party at Government House. To the Government of the Province, as represented by the Minister of Education, we must express our full recognition of courtesies extended. To the ladies of Toronto, the members of the Association are deeply indebted for the private hospitality which has been organized in their behalf. Carriages have been furnished, garden parties and receptions have been given, and all with a tact and cordiality of the most earnest kind. Never in the history of the Association has the social side of a meeting been so charmingly developed. To the Press of Toronto we offer thanks for the thoroughness and fairness with which the reports of the meeting have been prepared, and for the many friendly editorials which it has published, giving voice to the public interest in our proceedings. To the Toronto Amateur Association, the Canadian Institute, the Granite Club, and Royal Canadian Yacht Club we acknowledge the courtesies shown us in giving the members of the Association the privileges of their rooms; also to the railway companies

for reduced rates of fares, and to the Canadian Express Company for transportation of apparatus and specimens, and to the great North-Western Telegraph Company for the free use of its wires we desire to express our gratitude. Finally, to the many friends who have rendered services so delicately and modestly as to remain themselves personally unknown, we must express our warmest appreciation. Though they cannot be thanked in name our gratitude is none the less perfect and sincere.

In support of these resolutions Professor EASTMAN, of Washington, acknowledged especially the efforts of the Local Committee and dwelt upon the success of the meeting so largely due to their generous provisions.

Professor GOODALE of Cambridge, in adding thanks, paid a high tribute to the University and commended it to the support of the people of the Province.

Professor MORSE of Salem dwelt upon the fellowship in science irrespective of geographical limits.

Professor COMSTOCK of Madison, acknowledged the generous hospitality of the ladies of Toronto, and presented the following communication signed by ladies attending the meeting:—

"The undersigned, ladies attending the Toronto meeting of the Association for the Advancement of Science as active and associate members thereof, desire hereby to express to the Ladies' Local Committee, collectively and individually, their sincere acknowledgments for the many courtesies and kind attentions which have been extended to them during the present meeting; courtesies and attentions, too, which have been as elegant and generous on their part, as they have been acceptable and grateful to us."

Professor PUTNAM of Cambridge referred to the work of the Canadian Institute and expressed the hope that it would be loyally supported in its undertakings.

The resolutions were then unanimously adopted.

Sir DANIEL WILSON in humorous and kindly expressions acknowledged the resolutions on behalf of the University of Toronto.

Hon. G. W. ROSS, Minister of Education, replied on behalf of the Province of Ontario, expressing satisfaction with the result of the meeting in stimulating education, and pleasure that the direction of education had found such warm commendation.

Prof. GOLDWIN SMITH, on behalf of the citizens of Toronto, dwelt upon the kindly feeling between the United States and Canada and the brotherhood of its citizens.

Prof. CHARLES CARPMAEL, Chairman of the Local Committee, replied on its behalf that it had found naught but pleasure in its labors and felt pleasure and satisfaction in the appreciation shown by the American Association.

President MENDENHALL after a few concluding remarks declared the adjournment of the Session.

C. LEO MEES,

General Secretary.

REPORT OF THE PERMANENT SECRETARY.

For the third time the Association has shown its continental character by holding a meeting beyond the political boundaries of the United States, thus proving its right to be called American in the widest acceptance of the term. It may now be expected that at no very distant time a meeting will be held in Mexico, which would prove advantageous in many ways, and add still more to the helpful influence of the Association in the advancement of American science.

Without making any disparaging comparisons, it is only simple justice to state that the cordial welcome given to the members in Toronto has never been surpassed, nor have the local arrangements for the meeting and the care taken of the members often been equalled. The members of the Local Committee were untiring in their efforts, and were heartily assisted by the government of the University and by the Provincial and City authorities. The general impression made upon the members of the Association was that the whole city joined in offering them a continual ovation.

The Queen's Hotel and the University building were the headquarters of the Association, and at both places everything possible was done to aid in the work of the meeting, and to assist the officers in their duties, both by the courteous proprietor and clerks of the hotel, and by the officers of the University; while the Local Secretary with several earnest fellow-workers on the committee were indefatigable in their voluntary labors in all directions.

In addition to the several halls in the great University building, the Chemical Laboratory and the new Biological Building on the grounds of the University of Toronto were used for the meetings of the sections. The morning general sessions were held in Convocation Hall and those in the evening at the Pavilion and at the Y. M. C. Association Hall in the heart of the city.

The partial destruction by fire, on February 14, 1890, of that beautiful structure of stone, the main building of the University of Toronto, containing the principal halls of the University, its valuable Library and its Museum, with many of the special class-rooms and laboratories of the professors, so soon after our meeting, has brought the University of Toronto still closer to the members of the Association who in August last were so cordially welcomed within the walls of the picturesque stone building which in its massiveness seemed destined to stand for centuries. It is a satisfaction to know that the insurance and the grant by the Province will secure the restoration of the beautiful façade of the building and the rebuilding of the interior with many improvements. The city of Toronto, the alumni and friends of the University have also made contributions towards the erection and equipment of other buildings. It still remains, how-

ever, for the friends of education, everywhere, to make such contributions as they can to the Library, Museum, and other departments, totally or partially destroyed by fire. Certainly there could be no better way of showing an appreciation of the kindness with which the Association was treated during its meeting in Toronto, than by a hearty giving of books, specimens, and apparatus to the University by the individual members of the Association, almost everyone of whom must have some volume or object which would prove of value to the University. All such gifts should be addressed to Sir Daniel Wilson, President of the University of Toronto, Ontario.

While for various reasons it was considered best to begin the meeting in the last week of August, as was determined at the Cleveland meeting, there was a general feeling that had it been held a week earlier the attendance would have been much larger; as it was, 424 members and associates were registered from the following places:—

Toronto, 46; other parts of Canada, 29; New York, 88; Washington City, 49; Pennsylvania, 35; Massachusetts, 25; Ohio, 22; Illinois, 16; Michigan, 16; Iowa, 11; Indiana, 11; Maryland, 10; Connecticut, 10; New Jersey, 8; Wisconsin, 6; Kentucky, 5; Tennessee, 5, Nebraska, 4; Texas, 4; Kansas, 3; Arkansas, 3; West Virginia, 3; Mississippi, 3; New Hampshire, 3; Maine, 2; Missouri, 2; Minnesota, 1; Dakota, 1; Utah, 1; Rhode Island, 1; Louisiana, 1.

Of the 197 members elected at the Toronto meeting, 152 have perfected their membership, also 1 elected at Cleveland; 39 members have paid their arrears and have been restored to the roll, making 192 names added to the roll since the Cleveland volume was published. From the Cleveland list 43 names have been transferred to the list of Deceased Members, 32 members and fellows have resigned and 124 have been omitted for arrearages, making a deduction of of 199 from the list. 2 have become life members; 63 members have been transferred to the roll of fellows. Of the 1956 now on the roll, 247 are at this date in arrears for the Cleveland and Toronto assessments, and 288 for the Toronto assessment alone.

The following is a comparative statement of the roll as printed in the Cleveland volume and in the present volume.

	Cleveland.	Toronto.
Patrons	3	3
Members	1271	1229
Honorary Fellows	1	1
Fellows	689	723
	1964	1956

The report of distribution of volumes was omitted in the Cleveland volume of Proceedings. The following record, therefore, is for two years:

Memoirs, No. 1: sold 1, exchange 1, presented 4.

Vols. 1–35: delivered to members 134; sold 121; exchanges 56; presented 73; returned by exchanges 14; bought back, 8.

Vol. 36: delivered to members 1560; sold 32; exchanges 233; presented 5; duplicate copies to members 3; returned by exchange 1.

Vol. 37: delivered to members 1629; sold 47; exchanges 234; presented 5; duplicate copies to members 2.

Included in the copies presented is a full set of the publications to the Public Library of Toronto, and another set sent to the University of Toronto since the fire.

Of the 227 titles of papers received, 16 were declined by the Council as not suitable to the Association or for lack of proper abstracts. The 211 accepted papers were read as follows:—In section A 24, B 28, C 21, D 10, E 36, F 34, H 39, I 19. Of these 133 are printed in the present volume, either in full or by abstract, and 78 are mentioned by title only. Of many of the latter, abstracts would have been printed had they been given to the secretaries of the sections before the close of the meeting. In other instances the papers have been printed in full elsewhere. The present volume also contains the address by the Retiring President, the addresses by seven Vice Presidents, and the reports of eight committees. In addition to the addresses and papers recorded in the volume, two public evening lectures were delivered by Dr. Bolton and Mr. Gilbert.

As will be seen by the cash account on the following pages, the current debt of the Association, which has been of a greater or less amount for a number of years, was paid off in full at the time of closing the cash account just prior to the Toronto meeting.

The RESEARCH FUND on Aug. 1, 1889, principal and interest, amounted to, ...	$4,424.97
Commutations of assessments, 1888–9, ...	200.00
Gift of a lady member at Toronto, ...	500.00
	$5,124.97
By vote of the Council at Toronto, $150 was granted to Professor Morley in aid of his Measurements on the Velocity of Light in a Strong Magnetic Field; and $50 was granted to Professor Atwater for experiments under his direction relating to Heat of Combustion of certain Compounds, ...	200.00
To these grants were added $100 each from the above recorded gift at the request of the donor, . .	200.00
	$400.00
Leaving amount of Research Fund, ...	$4,724.97
The GENERAL FUND, Aug. 1, 1889, principal and interest,	$116.53

The Association is thus not only free of debt, but has invested funds as above stated, and is able to make grants of two or three hundred dollars a year in aid of research.

F. W. PUTNAM,

Permanent Secretary.

Salem, Mass., June 18, 1890.

F. W. PUTNAM, PERMANENT SECRETARY,

Dr. THE AMERICAN ASSOCIATION FOR

1888–89.

To admission fees Toronto Meeting	$ 15 00	
" " Cleveland "	655 00	
" " previous to Cleveland . . .	5 00	
Fellowship fees	72 00	
		$747 00
Assessments previous to Cleveland Meeting .	669 00	
" for Cleveland Meeting	3,210 00	
" " Toronto Meeting	798 00	
" Associates, Cleveland	108 00	
		4,785 00
Publications sold	62 81	
Binding	72 20	
Postage and express refunded	1 78	
Incidental receipts	25	
		137 04
Gift of Alex. S. Webb of New York	5 00	
Life Membership commutations	200 00	
Research Fund income	200 00	
		405 00
From a Cleveland friend to balance account .		83
		$6,074 87

I have examined the above account and

SALEM, MASS., AUGUST 24, 1889.

IN ACCOUNT WITH

THE ADVANCEMENT OF SCIENCE.

		Cr.
		1889–89.
By 2500 copies Proceedings Vol. 37 (586 pages)		
Composition and authors' changes	$1,012 12	
Paper and press work	967 50	
Printing paper covers and binding 2400 copies	264 00	
		2,243 62
Binding 25 copies Vol. 37, half morocco	25 00	
" 75 " " " cloth	37 50	
Cloth covers, 25	5 00	
Printing wrappers and wrapping 2500 Vols.	34 50	
2750 extra copies of addresses and reports	108 35	
		210 35
Expenses of Cleveland Meeting	221 17	
Constitution and list of members, Cleveland	35 00	
Paid Salem Press through George F. Barker	50	
Express, including distribution of Vol. 37	250 83	
P. H. Dudley for postage and express	2 85	
Postage, stationery and P. O. Box rent	177 85	
Telegram and telephone	4 51	
		436 04
Proceedings bought	4 00	
Printing circulars, blanks, tickets, cards, etc.,	86 71	
Petty expenses	8 28	
Fuel	7 00	
Rent of office	108 00	
Janitor to Aug. 1, 1889	100 00	
		313 99
Grant to F. W. Putnam in aid of archæological explorations, from income of Research Fund		200 00
Salary of Permanent Secretary to Aug. 1, 1889	1,250 00	
" " Assistant " " " " "	500 00	
		1,750 00
Carried to Life Membership Fund		200 00
Paid amount adv. by Perm. Sec'y, 1887–8 account		468 70
		$ 6,074 37

certify that the same is correctly cast and properly vouched.

HENRY WHEATLAND, *Auditor.*

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